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## ORIGINAL ARTICLES.

### I.—On the Origin and Mode of Formation of the Concretions in the Magnesian Limestones of Durham.

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(PLATES XII. and XIII.)

In 1826, 27, and 28, Prof. Sedgwick contributed to the Geological Society of London his classical papers on the Magnesian Limestone of the East of England,[1] in which he describes in detail the concretionary structures which occur in many of the beds of this formation in Durham.

Although he describes these concretions in minute detail, he says but little as to their probable origin, but it is clear that he regarded them as composed of carbonate of lime derived from the beds in which they occur, when he says—"The particles (of lime), after deposition, appear to have run into lumps and masses more or less crystalline, rejecting great portions of the earthy residuum."[2] Since Prof. Sedgwick's papers little seems to have been contributed to the subject of the mode of formation of these concretions.

Two opposite opinions are held with regard to the proximate source of the carbonate of lime:—One to the effect that the lime was introduced into the concretionary bed subsequent to its formation, in solution from without; the other that it was deposited contemporaneously and subsequently segregated out *in situ*.

The latter opinion is, we believe, that generally held,[3] though there are some who advocate the former, which may be called "the [illegible]"[4] theory.

Looking at the Magnesian Limestone series as a whole, many of the concretionary structures appear as if they might have been formed in the stalactitic manner supposed; but when the individual beds containing the concretions are studied in detail, they are found to present many points which appear irreconcilable with the theory of their stalactitic origin.

The locality where these beds can be most satisfactorily examined

[1] Prof. Sedgwick, "On the Geological Relations and Internal Structure of the Magnesian Limestone," Trans. Geol. Soc. London, 2nd series, vol. iii. 1835.

[2] *Op. cit.* p. 89.

[3] Prof. Green, Physical Geology, p. 279; Geikie, Textbook of Geology, 1885, p. 472.

[4] R. Howse, "On the Stalactitic Origin of Conglobated Structures in the Magnesian Limestone," Tyneside Naturalists' Field-club, October, 1889.

is at Marsden quarries on the coast of Durham, between Sunderland and South Shields, where masses of stratified limestone are interbedded with marls containing concretions in every stage of development. Where fully developed, the concretions assume a spherical form, and are sometimes as much as 1 to 2 feet in diameter, the average size being from 3 to 6 inches. They are composed of fibrous crystals of calcite radiating symmetrically from the centre, which frequently consists of a valve of *Ascinus dubius* or *Myalina Hausmanni*. (See Plate XII. Fig. 1.) Very often, however, the centre is composed merely of a small cavity.

These concretions occur in irregular masses 20 to 30 feet thick, showing here and there rough stratification, and often passing laterally into well-bedded limestone. Many of the larger specimens show well-marked concentric bands developed at regular intervals.

The concretions are piled on one another with but scant matrix between; chemically they consist of 91 to 95 per cent. of carbonate of lime and 1·5 to 4 per cent. of magnesia.

It is difficult to see how such masses of limestone could have been formed by infiltration from beds above. Where are the beds into which the carbonate of lime dripped during the formation of the concretions? If we suppose these concretions to have been formed from carbonate of lime introduced in solution from an overlying bed subsequent to the consolidation of the deposit in which they occur, then the original bed, now replaced by concretions, must have disappeared. But this bed would originally contain 20 to 30 per cent. of magnesia, which must have been subsequently dissolved out; yet it is hardly likely that water which was saturated with carbonate of lime would dissolve out carbonate of magnesia the less soluble salt of the two,[1] and we cannot suppose that the magnesia bed was dissolved out first, leaving an enormous cavity into which the carbonate of lime afterwards dripped, forming around shells suspended in some mysterious manner; the symmetrical development of the concretions also, which is as perfect vertically upwards from the nucleus as it is laterally and vertically downwards, seems to preclude the possibility of their having been formed in a previously-solidified rock-mass.

Again, the shells forming the nucleus of the concretions are often in beautiful preservation, which is hardly likely to have been the case if they had lain in a porous bed exposed to the action of infiltrating waters, while in those cases where the centres are hollow it is impossible for the carbonate of lime trickling through the beds in solution to have crystallized out round a cavity, whereas we can easily imagine the centre to have originally consisted of an organic body in the sediment which, serving as the nucleus round which concretionary action was set up, afterwards decomposed.

But it is in the beds containing immature concretions in various stages of growth that the strongest arguments against the formation of the concretions by stalactitic action are supplied.

[1] Hardman, Carbonif. Dol. of Ireland, Proc. Roy. Irish Acad. vol. ii. ser. 2, 1877.

These beds consist of friable yellow marl, in which are imbedded hard sphæroidal concretions often much flattened. The concretions consist of 85–95 per cent. of carbonate of lime, and 6 to 12 per cent. of magnesia, while the matrix often contains as much as 50 parts of magnesia on 100 of carbonate of lime.

The beds are markedly stratified, the lines of bedding passing uninterruptedly through matrix and concretions alike. (See Pl. XIII.)

This fact was first noticed by Prof. Sedgwick, and it is perhaps the strongest argument in favour of what we may call the 'Segregation' theory. The advocates of the 'Stalactitic' theory refer these lines of stratification in the concretions to lines along which the carbonate of lime spread out when dripping from above in solution; but this does not account for the individual lines of bedding passing uninterruptedly from matrix to concretion, nor does it account (if the formation is still supposed to be taking place) for the fact that where the beds dip at a considerable angle, the lines in the concretions are still parallel to the general bedding of the rock, not parallel to the horizon, as would be the case if they were being formed up to the present day by infiltration.

These flattened concretions contain numerous small shells disseminated through them, notably *Pleuropterus costatus* and *Turbo helicinus*, whereas these appear to be altogether absent from the matrix. This we should expect according to the 'Segregation' theory, the shells being the nucleus round which the carbonate of lime segregated, and any fossils remaining in the matrix, which is extremely porous, would, after the solidification of the bed, be readily dissolved out by subsequent infiltration, whilst those embedded in the concretions would be protected by their impervious covering of hard limestone.

These fossils are frequently found projecting from the sides of the concretion along lines of bedding, in the same way that one-half of a sponge spicule, or other organic body, is found embedded in a flint, while the other half projects into the surrounding chalk.

It is difficult to account for the presence of fossils in these flattened concretions if we assume their stalactitic origin, as we cannot suppose them to have been introduced in solution, and to have reformed as fossils on the solidification of the concretion.

Turning now to the chemical side of the question. It had been hoped that a detailed chemical investigation of these beds would have conclusively proved by which of the two processes under consideration these concretions had been formed. For supposing the average analysis of the beds containing concretions to have agreed with the analysis of beds containing no concretions, we should have been justified in concluding that the carbonate of lime, of which the concretions are mainly composed, had not been introduced from overlying beds in solution, but had been originally deposited as part of the bed in which they are now found; but the complicated nature and variable chemical composition of the different beds of the series cause the evidence so afforded to be less certain than had been hoped, although the results are by no means valueless in this connexion.

The great drawback to the evidence is the very variable composition of those beds in which no concretions are developed, and the difficulty of selecting a bed or beds representing the original composition of the deposit, as regards the relative quantities of carbonate of magnesia and carbonate of lime present. In the annexed table are given average analyses of concretionary, stratified, and compact magnesian beds:—

| | I. | | II. | | III. | | IV. | | V. |
|---|---|---|---|---|---|---|---|---|---|
| | Matrix. | | Concretions. | | Average of I. and II. | | Overlying Bed. | | Roker Cliff. 100 feet. |
| Carb. Lime ... | 46·07 | 100·00 | 86·14 | 100·00 | 59·43 | 100 | 85·78 | 100 | 59·81 | 100 |
| Silicate ..... | 2·03 | | ·26 | | 1·50 | | ·09 | | — | |
| Carb. Magn.... | 30·68 | 66·74 | 9·5 | 11·0 | 23·62 | 40 | 6·5 | 7·5 | 26·06 | 43 |
| Peroxide Iron | 1·52 | | 1·8 | | 12·60 | | 2·0 | | 14·13 | |
| Alumina ..... | 16·58 | | | | | | 3·15 | | | |
| Insol. in HCl. | 3·00 | | 1·98 | | 2·5 | | 2·10 | | | |
| | 99·88 | | 99·68 | | 99·65 | | 99·62 | | 100·00 | |

Column I. gives an average of 12 analyses of the matrix which are each tested from 15 samples, the composition shown being thus the average of 180 samples. In the same way Column II. shows the average composition of 180 samples of the concretions.

The bed selected for examination is that shown in the photograph, (Plate XIII.), which extends for some 12 to 15 feet in a downward direction. It will be seen that whereas the matrix contains 66, the concretions only contain 11 parts of magnesia to 100 parts of lime.

The overlying bed (No. IV. of the Table) is a well-bedded limestone, which forms the surface beds in this district, and if the concretions had been formed stalactitically, it is from this bed that the lime must have been derived; but the bed shows no honeycombed appearance, and is one of the most compact members of the series. This overlying bed, which is 20 to 30 feet thick, is itself thoroughly concretionary in its structure, although on a minute scale, on the type of the globular concretions which overlie and pass into it, and if the lime forming the concretions is to be regarded as derived from infiltration, the whole of this upper bed must then have been formed in like manner, for we cannot fix an arbitrary size of concretion and declare that all those larger than this size were formed by infiltration and all those smaller, although of exactly similar structure, represent the bed as originally deposited. Since then the beds immediately overlying our concretionary bed are also concretionary, we cannot consider them as representing (according to the stalactitic theory), the original deposit, and we cannot use them therefore for instituting a chemical comparison with the typical concretionary beds. If, however, we go to higher beds, omitting those which have concretionary limestone interbedded with them, we find at Roker a massive bed nearly 100 feet thick; its composition, as given by Messrs. Browell and Kirkby,[1] is shown in Column V. of our Table.

In order to compare the composition of this bed with that of our bed of concretions, we must obtain the average composition of the latter, and to do this we must determine the relative proportions of concretions and matrix present. Numerous estimates along the exposure give roughly 2 of matrix to 1 of concretions as the approximate proportions, and working this out (Column III. of the Table), it gives us 40 parts of magnesia to every 100 parts of carbonate of lime, which will be found to agree very closely with the analysis of the Roker bed, which gives 43 parts of magnesia to 100 of carbonate of lime.

This entirely confirms the theory that the lime composing the concretions was derived from the beds in which they occur, and was not introduced subsequent to their deposition. We must, however, frankly acknowledge that there are two uncertain factors in this comparison, namely, the difficulty of arriving at an exact estimate of the relative proportions of matrix and concretions, and the somewhat arbitrary selection of the bed with which they are compared; as, however, great importance has been attached to a detailed chemical investigation of these beds, we give the results of our work in this direction, which confirm, as far as they go, what we have before alluded to as the 'Segregation' theory.

There is, however, other evidence in this direction derived from a study of the chemical composition of the concretions, namely, the presence in them of magnesia and insoluble matter.

The amount of magnesia, which is sometimes as much as 12 per cent., varies considerably in different concretions in the same bed, analyses of two concretions lying a few feet apart yielding in one case 2·3, and in the other 6·3 per cent. If the concretions had been deposited from percolating water, it is difficult to see why the water should vary at the distance of a few feet in the amount of magnesia it contained, whereas on the segregation theory we should expect the amount of impurities imprisoned during the process to vary from point to point, and it is still more difficult to account for the presence of insoluble matter, which is usually about 2 per cent., and in one specimen amounts to as much as 8·5 per cent. of the concretion.

The last argument against the stalactitic origin of this deposit that we have to bring forward is the fact that large quantities of calcite occur in these beds which *have* undoubtedly been formed by stalactitic action. They consist of pure white fibrous calcite,[2] and contain no magnesia or insoluble matter, they line cavities and cracks, and fill in the interstices between the concretions, often coating their surfaces to the thickness of an inch, and roughly modelling themselves on their external shape. These deposits, which here and there attain a thickness of 5 to 6 inches, can be traced to joints in the overlying beds through which the carbonate of lime has undoubtedly obtained access in solution, the walls of the joints

[1] Browell and Kirkby, on "The Magnesian Limestone of Durham," Nat. Hist. Trans. of Northumberland and Durham, vol. i. pt. 2.

[2] Not aragonite, as often described locally.

being lined with a similar deposit. Figs. 3 and 4, on Plate XII., show concretions coated with it. In many cases (Fig. 4) the calcite has begun to replace the original concretion, or perhaps add to its original mass, but this replacement is limited to about a quarter of an inch on the surface, and it never penetrates far, except when it fills cracks in the concretion. It is obvious, then, that it is either replacing the concretion from without inwards, or is forming on the surface of previously existing concretions, and its secondary nature is quite unmistakeable.

*Summary.*—We can then sum up the evidence against the stalactitic origin of these concretions under the following heads:—

I. *Stratigraphical.*—(*a*) The marked stratified condition of these beds as a whole, which would to a large extent have been obliterated by the copious infiltration necessary for the formation of the concretionary structures.

(*b*) The uninterrupted passage of the lines of bedding through matrix and concretions alike.

(*c*) The enormous thickness of some of the concretionary limestones.

(*d*) The fact that the concretions occur only in the Upper Magnesian Limestone, which is overlaid by the Triassic Marls and Sandstones, a deposit containing originally probably but little carbonate of lime.

(*e*) The fact that the concretions are confined to the Magnesian Limestone series.

II. *Evidence from fossils.*—(*a*) The occurrence of shells in the centre of the radial concretions.

(*b*) The occurrence of cavities at the centre, probably originally occupied by organic matter.

(*c*) The wonderful state of preservation of shells occurring in these concretions and the almost total absence of fossils from the earthy matrix.

III. *Chemical.*—(*a*) The great similarity in composition between the concretionary bed as a whole, and the massive beds higher in the series which contain no concretions, with reference to the relative amounts of carbonate of magnesia and carbonate of lime that they contain. Showing that it is unnecessary to assume the introduction of extra carbonate of lime from beds above.

(*b*) The variable amount of magnesia in contiguous concretions.

(*c*) The presence in the concretions of a considerable quantity of insoluble material.

(*d*) The presence of calcite in these beds which *has* undoubtedly been deposited by stalactitic action and which in appearance, composition, and behaviour is so dissimilar to these concretions.

Having shown that the carbonate of lime of the concretions has in all probability been derived from the beds in which the concretions occur, we should like to add a few words as to the manner in which they appear to have been produced.

That some of the carbonate of lime disseminated through the deposit was abstracted from the general mass, and segregated round definite centres of attraction, is doubtless true, and, as Prof. Green remarks, we may give to this process a name of its own and call it

'Concretionary Action," but it does not enable us any better to ealize the immediate cause of the process, or to understand the ıanner in which it was brought about. With regard to the first part f the problem, namely, the cause of the segregation, the following onsiderations may throw a little light on the subject.

The concretionary beds are usually crowded with fossils, and it is ound these fossils that the carbonate of lime has segregated out; ıey, together with other foreign bodies (probably for the most part rganic particles, and now represented by cavities), were the, so ɔ speak, chemical magnets which attracted to themselves the vailable carbonate of lime.

The Roker beds, on the other hand, which are quite unfossiliferous ut are, as shown above, approximately identical in composition, ontain no concretions.

It might be urged against this that the Middle Limestone, which ontains the most numerous assemblage of fossils in the whole ystem, has developed no concretions; but those beds contain a elatively large proportion of carbonate of magnesia to carbonate f lime, which, as we are about to point out, seems also to have ıfluenced the decision as to whether a certain bed should or should ot develope concretions.

The presence of carbonate of magnesia in the unconsolidated eposit appears up to a certain point to have assisted the segregation f carbonate of lime; but when the quantity of magnesia present eached over 30 per cent., it has prevented this segregation from ıking place, except in small local patches. On the other hand, in ıose beds which are composed of almost pure carbonate of lime, ıe concretionary structure is only developed in a minute form ıroughout the mass.

It would appear, then, from this that where the deposit was fairly ee from magnesia, the "concretionary action" started from so ıany centres, that no centre had time to aggregate more than a ıall quantity of lime to itself, before it came in contact with the rowing peripheries of neighbouring concretions, and its further rowth necessarily ceased. When, however, the deposit contained ıore magnesia, the particles of lime were consequently more ıdely separated, there was less inducement for individual effort ı the part of would-be centres, and only the larger and stronger ıes succeeded in attracting particles from the surrounding mass, ıd grew in size in proportion to their numerical scarcity; the ıstance from which they were able to draw particles increasing proportion with the increase of their mass. When, however, the roportion of magnesia present exceeded a certain amount, the stance between the particles of lime became so great, and their utual affinity was so weakened by this increased separation, that ɔ foreign body was sufficiently powerful to start the migration of rticles in its own direction, and the deposit solidified as an rdinary compact bed.

We have then in concretionary action a very analogous process to ystallization. When the solution of a salt is concentrated and

allowed to stand, it rapidly crystallizes, forming a mass of small crystals. If, however, the solution had been previously diluted, fewer and larger crystals would have been formed, and this dilution might have been carried to a point, after which further dilution would have prevented crystallization from taking place altogether.

That the presence of magnesia is the primary cause of the formation of the concretions is borne out by the fact that they are confined to this formation, although there are plenty of other limestones in the geological sequence in which they should otherwise have occurred. We may remark in passing that no argument in favour of the 'Stalactitic' theory can limit the application of that theory to these particular beds, for the character of the deposit into which the lime is supposed to have been introduced could have no influence whatever in causing that lime to be dissolved from the beds above.

The second part of the question, namely, the process by which the particles of lime were conveyed from their original positions in the deposit, and were aggregated round their respective nuclei, is a very difficult one to answer, and we do not appear to have advanced much towards the right understanding of this process since the days when Prof. Sedgwick wrote. Broadly, the process is comparable to the solution of sponge spicules in the chalk, and their redeposition round nuclei in the form of flints.[1] Carbonate of lime, and silica are, however, different material. What do we know about the pectous and colloid forms of carbonate of lime? It is true that the aragonite forming the shells of mollusca is an animal product, and may perhaps be analogous to the form of silica known as organic; and we know that it is frequently converted into calcite in fossil shells, showing that a rearrangement of the molecules of carbonate of lime does take place after the entombment of the shell. The carbonic acid and other gases given off from the decomposing organic matter in the deposit, and existing under considerable pressure, have probably played an important part in maintaining the particles of carbonate of lime in a state of molecular suspension, in which condition they were able to migrate to the nucleus which was irresistibly attracting them. Whether this state was one of true solution as usually understood, or whether it was one analogous to the colloid condition of silica, it is impossible to say. Recent experiments on the combination of solids under pressure, and the movement of the individual molecules of a dry mixture, show that more rearrangement probably takes place amongst the particles of an unconsolidated deposit than we are accustomed to imagine.

[1] W. J. Sollas, Ann. and Mag. of Nat. Hist. 5th series, vol. vi.

## II.—The Recent and Rapid Elevation of the American Cordillera.

By Henry H. Howorth, Esq., M.P., etc., etc.

In some papers which have lately appeared in the Geological Magazine, I have endeavoured to show that the Ural Mountains, and also the great masses of high land in Eastern Asia from the Altai to the Himalayas, are of very recent geological origin, and that it was probably their rapid elevation which caused the great diluvial movement of which traces are to be found all over the Siberian plains. I now wish to call attention to some of the evidence which points to the American Cordillera being also a very recent geological feature, and dating from the same period of cataclysmic revolution which closed the Mammoth age.

It is a curious fact that one name, America, connotes both of the great continents hung together by the isthmus of Panama. The cause of this is of course purely historical, and yet it coincides with a great physical fact, namely, their essential unity in more than one respect. The generic unity of the old inhabitants of both continents is a peculiar fact in ethnography; but the unity is even more remarkable in this, that the vertebral column which runs north and south through the two Americas is essentially one backbone.

On this subject Humboldt writes with his usual lucidity and force. Speaking of the great chain of mountains that runs through both continents, he says: "This is the most continued, the longest, the most constant in its direction from south to north, and north-north-west, of any chain of the globe. It approaches the north and south poles at unequal distances of from 22° to 33°. Its development is from 2800 to 3000 leagues (20 to a degree), a length equal to the distance from Cape Finisterre in Galicia to the North-East Cape (Chukchoi-Noss) of Asia. Somewhat less than the half of this chain belongs to South America, and runs along its western coast. On the north of the isthmus of Capica and of Panama, after an immense lowering, it assumes the appearance of a nearly central ridge, forming a rocky dyke that joins the great continent of North America to that of the South. . . . As the continent beyond the parallel of Florida again widens towards the east, the Cordilleras, of Durango and New Mexico as well as the Rocky Mountains, which are a continuation of those Cordilleras, appear to be thrown anew towards the West, that is, towards the coast of the Pacific Ocean; but they still remain eight or ten times more remote from it than in the southern hemisphere. We may consider as the two extremities of the Andes, the rock or granitic isle of Diego Ramirez, south of Cape Horn, and the mountains that reach the mouth of the Mackenzie River (lat. 69°, long. 130½°), more than twelve degrees west of the Green Stone Mountains, and known by the denomination of the Copper Mountains" (Humboldt's Narrative, vol. vi. pp. 409–411).

It is to this chain chiefly that I wish to direct your readers.

The first and most remarkable fact to which I would draw attention is that throughout its vast length (in places towering to an

enormous height) there are only slight traces to be found of ancient glacial action, *except in* the length which separates Chili and Patagonia. Excluding this length, there are hardly any scratched boulders, roches moutonnées, or polished or striated surfaces which we can assign to that vast ploughshare of ice which has left its mark so plainly written on the flanks of the Alps and the Dovrefelds, the granite wastes of Labrador and the North-Eastern parts of America. Upon this point the best observers are unanimous.

We will first turn to South America.

It was Darwin who first drew attention to the distribution of boulders in South America. Humboldt had argued that, inasmuch as they are never found in the great intertropical plains of the Eastern side of America, they are entirely absent from the whole continent. Referring to this conclusion, Darwin says: "As far as I am able to discover from the works of travellers, and from what I have myself seen, the remark holds good in the countries on both sides of the Cordillera as far south as Central Chile. Azara has particularly stated such to be the case in Chaco. With respect to the tributaries of the Amazons, nothing can more strongly prove it than La Condamine's story" (Darwin's Narrative, p. 289). He says: "Below Borja even for 400 or 500 leagues, a stone, even a single flint, is as great a rarity as a diamond would be. The savages of those countries do not know what a stone is, and have not even a notion of it. It is diversion enough to see some of them when they come to Borja, and first meet with stones, express their admiration at them with signs, and be eager to pick them up, loading themselves therewith as with a valuable merchandize. . . . Neither in the southern nor in the northern hemisphere do the fragments, coming from the Polar regions, or from other mountain groups, arrive within a considerable distance of the lines of the tropics" (Darwin's Narrative, pp. 288–9). In the Appendix he says: "The lowest latitude in South America, in which I found large angular fragments, which must have been transported by ice there formed, or by some unknown means, was in latitude 41°. But as I did not examine the country immediately north of it, I am not prepared to say that this is their extreme limit, but between latitude 27° and 33° I found no appearance, on either side of the Cordillera, which indicated a power of transportation of the kind required to remove boulders from a distance. Thus we find that the limit of their dispersion in the two Americas is nearly the same" (*id.* p. 615).

Darwin curiously compares the Andes with the Himalayas in this respect. Thus he says: "We must couple the absence of erratic blocks along that part of the Andes which is situated under a warmer climate, with the similar non-occurrence, as I am informed by Prof. Royle, in Northern India round the flanks of the Himalaya, those loftiest pinnacles on the face of the globe" (*id.* p. 289).

What is true of South America is true of North America also. I must not be misunderstood. I am only speaking of the Rocky Mountains proper, which also are treated by Humboldt as in

essence identical with the Andes. I do not include the so-called Coast Range or the Cascade Mountains, or the Selkirk Range, or the Sierra Nevada. On all these there are traces of glacial action on a considerable scale; but in the case of the dominant range this is not so, and, except on some of the higher peaks, where the phenomena may have a very recent origin, there is a very singular absence of such phenomena.

In such a matter I cannot quote any one better than Mr. Clarence King. He writes:

"In the field of the United States Cordilleras, we have so far failed to find any evidence whatever of a southward-moving continental ice-mass. As far north as the Upper Columbia, and southward to the Mexican boundary, there is neither any boulder clay nor scorings indicative of a southward-moving ice-mass. On the contrary, the great areas of Quaternary material are evidently subaerial, not subglacial. The rocks outside the limit of local mountain glaciers show no traces either of the rounding, scoring, or polishing which are so conspicuously preserved in the regions overridden by the northern glacier. Everything confirms the generalization of Whitney as to the absence of general glaciation. . . . . Not more than a thirtieth part of the entire surface of the fortieth parallel area was ever covered by glacial ice. . . . . Whatever the greater causes may have been, the Cordilleran surface south of Washington Territory was free from an ice-sheet, and the only ice-masses were small areas of local glaciers which did not cover two per cent. of the mountain country."

Whitney also tells us that in the interior parts of the Cordillera the ancient glaciers usually extended down to about 7000 or 8000 feet above the sea (United States Geol. Expl. of the 40th Parallel, pp. 459–461 and 464).

In Dr. Wright's recently published "Ice Age in North America," we read:

"According to Whitney there are no signs of ancient glaciers in Western Nevada, though some of the mountains rise to a height of 10,000 feet. . . . . In Colorado there are evidences of ancient glaciers *only above the* 10,000 *foot line*. . . . . The most southern point at which signs of local glaciers in the Rocky Mountains have been noted is near the summits of the San Juan Range, in South-Western Colorado. Here a surface of about 25 square miles, extending *from an elevation of* 12,000 *feet down to* 8000 *feet*, shows every sign of the former presence of moving ice. Northward of Utah and Colorado the signs of former glaciation are of the same local character; that is, glaciers everywhere radiated from the higher mountain masses, and extended *a short distance* down the cañons and valleys. . . . . The glaciers of the Sierra Nevada and Cascade Range in California, Oregon and Washington Territory were on a much grander scale than those in the Rocky Mountains" (*op. cit.* pp. 148, 149).

Professor George Dawson, in criticizing some of Prof. Whitney's views, says:

"The general result arrived at in the areas of Whitney's and

King's surveys is that comparatively only a very small portion of the highest ranges of mountains has ever been covered with glaciers, and that there has never been in this region anything like a northern drift period or a transportation of material in any given direction independent of the present topographical features of the country" ("Nature," 1881, p. 290).

Again, Mr. G. K. Gilbert, in his report on the geology of Nevada, Utah and Arizona, says:

"About White's Peak in the Schell Range, Nevada, are the terminal moraines of five or six glaciers that descended to 8000 feet altitude in lat. 39° 15′. At about the same altitude and in lat. 39° are moraines and an Alpine lake upon the flanks of Wheeler's Peak, of the Snake Range of Nevada. Old Baldy Peak (N. lat. 38° 18′), near Beaver, Utah, overlooks two terminal moraines, one of which contains a lakelet at an altitude of about 9000 feet. No traces were seen of a general glaciation such as the Northern States experienced, and the cumulative negative evidence is of such weight that Mr. Gilbert is of opinion that the glaciers of the region referred to were confined to the higher mountain ridges" ("Nature," vol. xii. p. 299).

I will quote one more witness, and he the most important, because his remarks refer to the northern prolongation of the Rocky Mountains in latitudes where we should expect to see glacial phenomena on a very wide scale.

Professor George Dawson, the distinguished son of a distinguished father, has recently mapped out in detail the district threaded by the more northern parts of the Rocky Mountains, and what do we find on his map? Why, that while on the west of the chain the erratics, which were once shed by the Cascade Range, come almost up to the Rocky Mountains on the one hand, and on the east the drift, which has everywhere spread so far from Labrador and its neighbourhood, has similarly travelled right up to the flanks of the Cordillera, not an arrow or a mark is found on the map to show that the Rockies themselves threw off any erratics of their own, or that the great masses of ice which (one must suppose) covered them in the Glacial age, if they were then existing, formed any barrier to the spread of drift on either side of them. Assuredly the fact is a very extraordinary one.

North America presents to us the most gigantic traces of ice-action to be found anywhere. Nowhere else are the polished and striated surfaces so widespread, and the boulders and wreckage of ice-action so conspicuous. East and west of the Rocky Mountains the evidence is the same. How comes it, then, that the highest ground of all, which would naturally be looked upon as the main reservoir of the ice, should be so free from its marks, and should be so sharply contrasted with the mountains of Scandinavia, with the Alps, with the Cascade Range, and with the gathering ground of the Laurentian glacier? To my mind there is only one possible explanation of the facts here mentioned, namely, that the great American Cordillera, both in North and South America, is not only, as Elie de Beaumont affirmed, one of the newest mountain ranges

in the world, but that it only dates in its main features from that period of cataclysmic revolution in physical geography which closed the Mammoth age, and that it was not existing at the time of the so-called Glacial period.

This position may be supported, as similar evidence can be supported in the case of the Urals and other ranges. In the first place, it is a curious proof that the Rocky Mountains are very recent, that they do not constitute a real zoological boundary. On this subject I cannot quote a better authority than Mr. Murray, who, in his Geographical Distribution of Mammals, p. 313, says, "We should expect the Rocky Mountain range to form the chief longitudinal line of separation, but, as already said, it only separates species in a minor degree. The actual mountain barrier appears to be the Cascade Range on the west side of the Rocky Mountains, separating Oregon and California from the rest of North America; and the dividing limit between the two other regions seems to be the Nebraska country, on which lie the Mauvaises Terres and Nebraska, and Niobrara beds on this side of the Rocky Mountains—the line of separation, in fact, being marked by the site of the ancient Tertiary sea in which these beds had been deposited."

In the first place, it is a remarkable fact that the remains of the South American Mastodon of precisely the same species should have been found on both sides of the Cordillera of the Andes. It is incredible that an animal of the type of the Mastodon, which, as we know, fed on trees, should have traversed the high range over which the Alpaca and Vicuna can hardly pass. In North America the same fact presents itself, and we have remains of the Mastodon occurring in California and in Oregon, on the western side of the Rocky Mountains, as on the plains east of that range. This seems to me to be very strong evidence that the Cordillera was not existing in the Mammoth age to act as a zoological frontier.

Again, it was long ago observed by Humboldt that remains of the same animal occur on the high plateau of Quito and elsewhere at a tremendous elevation in South America, while the Mammoth left its bones on the high plateau of Mexico, thus offering a parallel to the remains from Hiundes in Tibet.

I will quote one or two instances in support of this contention. *Inter alia*, Humboldt discovered a large number of Mastodon remains in the so-called Giants' Camp at Santa Fé de Bogota, in Peru, at a height of 1300 toises (*i.e.* 2600 mètres) above the sea (*id.* p. 264). He found similar remains near the volcano of Imbaburra in the kingdom of Quito, also in Peru, at a height of 1200 toises (*i.e.* 2400 mètres) (*id.* p. 266). Others again at Chiquitos, near Santa Cruz de la Sierra, in 18° S. lat. and almost in the centre of South America. On the west of the Cordillera J. de Jussieu reports a great deposit of these bones in the valley of Tarifa at a distance of more than 130 leagues from the sea, and 200 from Potosi, while Humboldt sent one to Cuvier from Conception de Chili in 37° S. lat. (*id.* p. 267). Darwin also found remains of the Mastodon at Santa Fé, and speaks of their occurring up to the snow-line.

These facts are assuredly remarkable, and it is not strange, therefore, to find that Humboldt, after remarking how the bones of the great pachyderms scattered in the auriferous gravels on the flanks of the Urals prove the very recent origin of that chain, should go on to say: "Cette même conclusion de soulevement s'applique aux Andes, ou, dans les deux hemisphères sur les plateaux du Mexique, de Cundinamaska (near Bogota), de Quito et du Chili, on decouvre des ossemens fossiles de mastodontes à 1200 et 1500 toises de hauteur" (Geol. et Clim. Asiatique, pp. 381, 382, *note*).

See also his Relat. Hist. vol. i. pp. 386, 414, 429; vol. iii. p. 579.

Turning to another part, one curious feature of the Rocky Mountains pointing to their cataclysmic origin is the sudden and abrupt way in which they rise out of the adjoining plains. Thus Mr. Ball says: "The Rocky Mountain rises up from the midst as it were of a horizontal sea of red sandstone; as if some tremendous force had driven it upwards, like an island forced up from the depths of the ocean" (Silliman's Journal, vol. xxv. p. 35).

Reclus says: "La chaine des Montagnes Rocheuses ne projette pas de rameaux proprement dit dans les plaines orientales. Des terrains onduleux viennent se heurter au pied des Monts comme des ragues qui frappent les rocs d'un promontoire: la transition est brusque entre les escarpements et les plaines" (Nouvelle Geog. Univ. vol. xv.).

This is assuredly only consistent with this chain having been elevated by a local paroxysmic movement, and not by a slow general alteration of the level of the continent.

Another feature in which America and Asia resemble one another, and which points to a recent elevation of the land, is the fact of the existence of a number of small salt lakes which attest to wide areas of water having been recently drained. Thus, Mr. J. K. Gilbert, in his Geological Report, says that the level of what is now "Great Salt Lake must at one time have been much higher, and its area must have been much greater than it is at present. Former levels are marked by a series of conspicuous shore-lines carved on the adjacent mountain slopes to a height of more than 900 feet. When the waters rose to the uppermost beach, they must have covered an area of about 18,000 square miles, eleven times that of the present lake, and a trifle less than that of Lake Huron. The average depth was 450 feet, and the volume of water nearly 400 times greater than now." Mr. Gilbert believes "that the flooding of the Great Salt Lake Valley was contemporary with the general glaciation of the northern portion of North America, and with the formation of the numerous local glaciers of the western mountain systems, he considers it a phenomenon of the Glacial Epoch" ("Nature," vol. xii. p. 299).

Reclus describes the American salt wastes in his usual graphic manner. Thus, speaking of the desert of Utah, he says, "It is an immense surface of clay, dotted over with thin tufts of Artemisia; in certain places, however, it exhibits no trace of vegetation, and resembles a causeway of concrete, intersected by innummerable clefts, forming nearly regular polygons. In the midst of these

olitudes no rivulet flows, and no water spring gushes forth; only fter journeying for many a long hour the traveller sometimes omes upon some field of crystallized salt, a white expanse on vhich the clouds and blue sky are reflected as on the surface of lake. . . . . The solitudes of the Andes most resembling the desert egions of the old world and of the United States are the elongated lateaux, which rise one above another between the sea and the rincipal chain of the Andes, in southern Peru, and on the frontiers f Bolivia and Chili; such as the Pampas of Islay and Tamarugal, nd the desert of Atacama. The Pampa of Tamarugal has a mean ltitude of from 2900 to 3900 feet. It is a plain nearly covered vith beds of salt, or *salares*, which are worked like rock-quarries. The strata of salt are so thick, and rain is so rare upon the plateau, hat the houses of the village of Noria, which are inhabited by the vorkmen, are entirely constructed of blocks of salt. Some deserts situated to the east of the Tamarugal, on more elevated plateaux, ontain a still larger quantity of salt.

The Pampa of Sal, which is overlooked by the volcano of Isluga, as a mean altitude of not less than 13,800 feet, and its whole xtent, which is 125 miles long, and from 9 to 24 miles wide, is erfectly white. The depth of salt deposited upon this plateau aries from 5 to 16 inches, according to the undulations of the round."

"Whence do these enormous masses of salt proceed? Doubtless rom the sea or ancient lakes which formerly covered these countries, nd have been gradually emptied by the rising of the soil" (Reclus, 'The Earth," pp. 107–108, and 110–111).

We can hardly separate the drainage of these seas from the pheaval which uplifted great collections of bones of the Mastodon o a level close to the snow-line, and quite outside the range of the oft-wooded trees on which they fed. The Salt-licks of Ohio actually ontain great masses of Mastodon and other bones.

If we cross the Cordillera, both in North and South America, from west to east, we have another and equally difficult problem to solve, amely, to account for the vast and continuous beds of unstratified oam which, whether we call it Loess or Pampas mud, has the same tructure, and which no ingenuity can mistake for a deposit which as been thrown down by water in a gradual way, or been accumu- ated at all in a gradual way, since it not only has no signs of tratification, except in very local circumstances, but overspreads whole continents with its mantle, irrespective of the drainage or the ontour of the country, and which seems unmistakeably to prove the peration of some rapid and cataclysmic cause.

In regard to South America some of the most distinguished eologists, such as D'Orbigny, Brongniart, Elie de Beaumont, etc., ave not scrupled to explain it as a consequence of the sudden or very rapid upheaval of the Andes. D'Orbigny, who is much the most distinguished geologist who has written on South America, which he explored so diligently, and upon which he published a most magnificent work, is very emphatic on the subject, and I must quote some passages from his too little consulted masterpiece.

The Pampas deposit, he tells us, covers an area of 23,750 square leagues, and rises gradually from the sea-level to a hundred mètres or more. It also fills small elevated valleys as at Tarija, at Cochabamba, 2575 mètres above the sea, and all the Bolivian plateau at the mean height of 4000 mètres; so that it occurs at all heights from the sea to the summit of the Cordilleras. It consists of a homogeneous reddish unstratified loam. It is the same at Chiquitos and Moxos, while on the Rio Piray it is somewhat mixed with clay, and is the same on the high plateaux as it is on the Pampas, and only contains Mammals' bones. It covers, in fact, the surface of nearly all South America, and is the result of one general cause (D'Orbigny, vol. iii. pt. 3, pp. 250, 251). It covers deposits of all ages—Silurian, Devonian, Carboniferous, Triassic and Trachytic (*id.* p. 253). If, as Darwin argued, this deposit was of fluvatile or estuarine origin, how, says D'Orbigny, can we explain its presence both on the plains and the high plateaux? This makes it clear that its cause was not a local but a general one (*id.* p. 255).

Another fact which points the same moral is the absence of stratification in these loamy beds. In certain places it is harder or more or less sandy; but these parts, far from being separated from the rest by horizontal lines, which always show themselves in beds deposited slowly from water, form one mass with indistinct zones which are very transient. In one word, it may be said that the Pampas mud was deposited in a very short time and was the result of a great terrestrial commotion (d'Orbigny, vol. iii. pt. 3, p. 73).

Elsewhere he explains what, in his view, was the nature of this commotion. He tells us how great dislocations took place in the bed of the ocean to the west of the American continent. This dislocation was coincident with the sudden or rapid upheaval of the Andes over a length of 50 degrees or 1250 leagues. This upheaval caused the sudden movement of the sea, which invaded all at once the continent, carried off and overwhelmed the Mastodons which inhabited the eastern flanks of the Bolivian Cordillera, the Megatheriums, Megalonyxes, and the multitude of animals daily being discovered in the caverns and the fissures of the mountains of Brazil—all the species, in fact, which are extinct. It was then, perhaps, that, mixed with the earth, the animals were tumultuously deposited in the lower parts of the Tertiary basin of the Pampas, and thus formed the immense deposit of Pampas mud (*op. cit.* vol. iii. pt. 3, p. 82).

Again he says: "My final conclusion from the geological facts I observed in America is, that there was a perfect coincidence between the upheaval of the Cordilleras, the destruction of the great race of animals, and the great deposit of Pampas mud. Thus these three questions of immense importance for American geology and for the chronological history of faunæ, may be explained by one cause, namely, the upheaval of the Cordilleras, to which we may, perhaps, attribute the analogous phenomena of which Europe has been the theatre" (*id.* vol. iii. pt. 3, pp. 85, 86).

Elsewhere again he points to other facts which prove more directly the coincidence in time of the rise of the Cordilleras and the deposit of the Pampas mud by the waters as the result of this elevation are without doubt the numerous depressions and denudations which cut into the soil from east to west, and the dispersion of porphyry boulders over all the Tertiary deposits of Patagonia. If these denudations had been subsequent to the deposit of the Pampas mud, it is evident that the porphyritic boulders with which the ground is covered over round the circumference of the Pampas would also have covered the Pampas deposit, whereas they cease just where the Pampas mud begins, as Darwin showed when he says they are found from the Straits of Magellan to the Rio Colorado. We may thus look upon the elevation of the Cordilleras as the cause which at the same time drove the water from West to East with sufficient violence to denude the Tertiary soil in the direction of the slope, and to sweep from the Andes the porphyry boulders which cover all Patagonia, and we may see in the same fact the reason why the vegetable soil, etc., was swept from all the Tertiary strata of Patagonia to be deposited in the great reservoir of Pampas mud.

I hold that the waters which deposited the Pampas mud were salt, because all the clay deposits of the Upper Andes containing bones are saline. It is so also with the Pampas mud, which shows efflorescence at different points. But the best proof is the existence of salt lakes dating from this period at the summit of the Cordilleras, and in all the depressions caused by water in the plains of Patagonia, and this perhaps accounts for the salt springs occurring in various places" (D'Orbigny, vol. iii. part 3, p. 82, etc.).

These views were shared by other inquirers. Thus in a report to the French Academy on the discoveries made by Lund in Brazil, we find the reporters, Brongniart, Dufrenoy, and Elie de Beaumont, saying, "The deposit in Brazil only differs from that of the Pampas by the presence of quartz pebbles, probably derived from subjacent beds; there it is from 3 to 16 mètres thick, and extends up the flanks of the mountains to a height of 2000 mètres." Mr. Lund attributes the red loam of Brazil to a great irruption of waters which covered all this part of the earth, and put an end to the existence of living animals. "Whatever modifications this hypothesis is destined eventually to suffer, it seems to us evident," say the learned reporters, "that the extension of the Pampas mud over the mountains of Brazil upsets the theory that this mud was deposited tranquilly in the estuary of a great river, and this extension seems very probable, since the Brazilian mountains are not the only ones where it occurs." . . . . The area covered by the Pampas mud is equal to that of France, and the deposit which contains Megatherium, Megalonyx, Hoplophorus, and Mastodon, on the Parana, is 200 myriamètres from Minas Geraes, where Lund found the same animals, proving that the cause of their deposition operated on a great scale over the continent of America, and that we must invoke, if we are to explain it, some general and widespread cause.

I have not pretended in this short paper to do more than collect

a few salient facts, which might be greatly multiplied. They seem to establish that the American Cordillera, like the Highlands of Eastern Asia, form a very new feature in the physical history of the world. They show that their upheaval dates very largely from post-Tertiary times, that it was very rapid, if not sudden, and that it caused a widespread diluvian movement, to which we must attribute the destruction of a large part of the Pleistocene fauna, and the spreading of the great mantles of unstratified loam in the Pampas of South America, and the Loess districts of the North.

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## III.—On the British Earthquakes of 1890, with the exception of those felt in the Neighbourhood of Inverness.

By Charles Davison, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

THE most remarkable earthquakes of the year 1890 were those felt in the district round Inverness between November 15 and December 14. These have been described in a separate paper.[1] The remaining earthquakes were of comparatively slight intensity. Two or three were felt during the night of June 25–26 within a very small area to the north-east of Leeds, and one at least in Kintyre on July 24. Several slight shocks at Invergarry and Feddan, in Inverness-shire, complete the list so far as known to me, with the exception of a doubtful shock at Tulliallan in Perthshire on January 6.

It is hardly necessary to do more than refer here to the two supposed earthquakes felt on January 7 at and near Chelmsford. In a letter to "Nature,"[2] I have given the evidence in full; and it appears to me sufficient to show that they were merely the reports of one of the great Woolwich guns. The reasons of this conclusion are, briefly: (1) exactly at the times given (12h. 30m. and 13h. 25m.), a 110-ton gun, the heaviest in the service, was fired at Woolwich; (2) the wind was S.W. over nearly the whole of England on the day mentioned, and all the places from which I have received records are close to a line passing in a north-easterly direction from Woolwich; and (3) the descriptions of the shocks show that they were due to impulses transmitted through the air rather than through the earth.

### Yorkshire Earthquakes: June 25–26.

*a.* June 25, about 22h. 30m.; Intensity, IV.; Epicentrum, about half a mile N.E. of Walton.

*b.* June 26, about 1h.

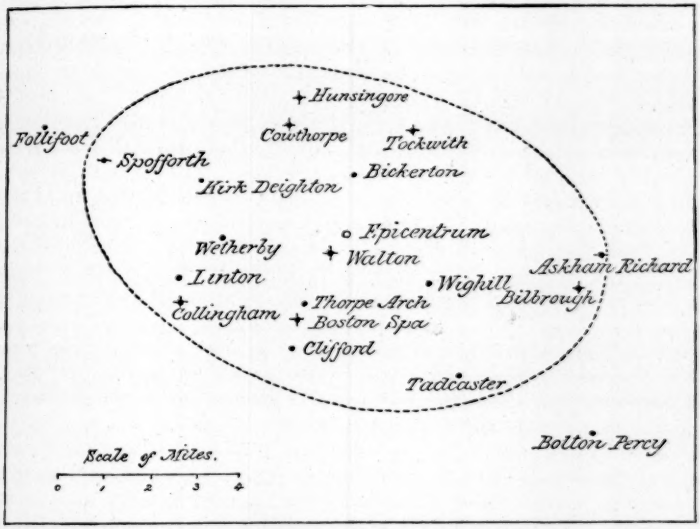
*First Shock*: *June* 25, *about* 22h. 30m.—I have received records of this shock from 19 places, which, with two exceptions, lie within an area about 11½ miles long and 7 miles broad; the direction of its longer axis being about W. 17° N. and E. 17° S. The boundary-

[1] Read before the Geol. Soc. on June 24.

[2] "Nature" (Feb. 20, 1890), vol. 41, p. 369.

line of this area corresponds to an isoseismal of intensity IV. or nearly so; it contains a little more than 60 square miles.

Throughout the disturbed area, the shock seems to have consisted of a single vibration; no tremulous motion being noticed either before or after. At Boston Spa, it is said to have resembled "an explosion, or the sudden and loud banging of a subterranean door." At Walton, a village close to the epicentrum, the movement was lateral only, no vertical motion being perceptible.




*Yorkshire Earthquake, June 25, 1890.* (22h. 30m.)

Estimates of the duration are variable, and probably include that of the accompanying sound in one or two cases. At Collingham, the shock seemed to be instantaneous. It is stated to have lasted a second or two at Boston Spa, two seconds at Hunsingore, about three seconds at Walton, and about ten seconds at Tockwith.

The intensity was IV. at Askham Richard, Bilbrough, Boston Spa, Cowthorpe, Spofforth, Tockwith, and Walton; and III. at Bolton Percy.

Sounds were heard accompanying the shock at eight places at least; from eight others no record is given on this point; at three places, Askham Richard, Bolton Percy, and Spofforth, it is expressly stated that no sound was heard. The sound-area was, therefore, somewhat less extensive than the disturbed area.

The epicentrum is about half a mile N.E. of the village of Walton, and 13 miles N.E. of Leeds.

*Second Shock*: *June* 25, *about* 1 h.—This shock was felt by several persons at Boston Spa, but I have not been able to obtain any detailed observations.

On the same day, at about 4h., a third shock is said to have been felt, at Wetherby; but, in the absence of any further information, its occurrence must be regarded as doubtful.

*Origin of the Shocks.*—In the immediate neighbourhood of the epicentrum, there appears to be no fault with which these earthquakes may be connected: at any rate, none is marked upon the Survey map. The evidence given above, slight as it is, seems to me also rather to oppose than to favour the view that they were fault-formed shocks.

Somewhat similar shocks, though disturbing smaller areas, are of frequent occurrence at, and in the neighbourhood of, Sunderland. These have been studied and discussed by Prof. G. A. Lebour in an admirable paper "On the Breccia-gashes of the Durham Coast, etc."[1] The magnesian limestone at Sunderland is about 400 feet thick. It contains numerous caverns, many of them naturally formed, some probably artificial owing to the withdrawal of water by the local water company. Fragments of rock must frequently fall from the roofs of these caverns, and it is to the concussions produced by them that Prof. Lebour, with very good reason I believe, attributes the Sunderland shocks. That such falls have frequently taken place in former times is obvious from the constitution of the numerous "breccia-gashes" which may be seen along the coast of Durham. That they are probably continuing at the present time is shown by evidence which has been obtained since the publication of Prof. Lebour's papers. The Sunderland shocks are especially numerous at certain parts along the banks of the Hendon Burn, a small stream about a mile south of the River Wear. The Sunderland and Ryhope Road crosses the stream nearly at right angles, and, for a distance of about 400 yards on the north side, and about 150 yards on the south side of the stream, it has been found that the road has recently subsided. The Ordnance Survey levelling of the road was carried out in 1857, and in 1887 the levelling was repeated by a well-qualified surveyor at the instance of Mr. T. W. Backhouse, of Sunderland. The average subsidence of the road over the distance mentioned was found to be 1 foot 10 inches in the thirty years; at the stream itself the subsidence was 2 feet 4 inches. A large part of this subsidence seems to have taken place towards the end of this period; for, in four years, 1883–87, Mr. Backhouse found by observations of a distant chimney, that his observatory, which is close to the Ryhope road, had been lowered by 1 foot 4 inches, and it is worthy of notice that just about this time the slight shocks became especially frequent.

The part of the disturbed area surrounding the epicentrum of the first of the Yorkshire shocks consists also of magnesian limestone, though its thickness is less than at Sunderland.[2] The depth of the

[1] Trans. of the N. of Engl. Inst. of Mining Eng. (Newcastle-upon-Tyne), vol. 33, 1884, pp. 165–174. See also a paper by the same author, "On Some Recent Earthquakes on the Durham Coast and their probable cause," Geol. Mag. (1885), Dec. 3, Vol. II. pp. 513-515.

[2] In the neighbourhood of Tadcaster, the thickness of the Permian formation (Upper Marls to Lower Magnesian Limestone, inclusive) is 300 feet (Mem. Geol. Surv., Explanation of Quarter-sheet 93 S.W.).

seismic focus must have been very slight. This is shown by—(1) the smallness of the disturbed area considering the intensity of the shock; and (2) the horizontal direction of the motion at Walton, a village only about half a mile from the epicentrum. Bearing in mind also the nature of the disturbances, it seems to me therefore very probable that the Yorkshire earthquakes were due to the falling of masses of rock in caverns of the magnesian limestone.

*Authorities.*—A short account of the shock is given in the "Leeds Mercury" for June 27. But for most of the observations on which the above description is founded, I am indebted to the kindness of the following correspondents: Askham Richard, Mr. T. B. N. Miles; Bilbrough, Miss Metcalfe; Bolton Percy, the Right Rev. the Lord Bishop of Beverley; Collingham, Rev. G. L. Beckwith; Cowthorpe, Rev. S. H. Gaisford; Hunsingore, Rev. J. J. D. Dent; Spofforth, Mr. R. T. Vyner; Tockwith, Mr. F. M. Clarkson; Walton, Mr. E. B. Waite, F.L.S. The details with reference to the subsidence of the Sunderland and Ryhope Road are taken from a letter by Mr. Backhouse in the "Sunderland Daily Echo" for Dec. 6, 1887.

### Kintyre Earthquake: July 24.

Time of occurrence, 11h. 37m.; Intensity, V.

I did not hear of this earthquake until some months after its occurrence. Partly on this account and partly from the difficulty of obtaining information in a district so thinly peopled, I can give but little beyond a slight description. I regret this the more, as it would have been interesting to have traced its relations with the earthquake felt in the same district on July 15, 1889.

Most of the places from which I have received records are indicated on the map of the earthquake of 1889.[1] These places are Clachan, Glen Saddell, Gigha, Kilberry, Tayinloan and Whitehouse. At Clachan and Tarbert the shock was accompanied by a rumbling noise. Throughout the island of Gigha, to the west of Kintyre, a rumbling noise was heard, but the shock itself was not perceived. Neither shock nor sound was noticed at Bellochantuy, nor at Lochranza in the island of Arran.

With evidence so slight, it is not possible to determine the outline of the disturbed area. It cannot have differed much from that of the year before; towards the north and south its limits may have been about the same; but it did not extend so far towards the east. Its epicentrum, though probably not very distant from the village of Clachan, must therefore lie somewhat to the west of that of the earthquake of 1889.

With regard to the nature of the shock, I know very little. At Clachan, it began with a series of tremors "so sharp, short and quick as not to be easily counted." These increased in intensity until, at the end of twenty seconds, "a vibration was felt like what would be caused by a heavy stone falling from a very great height."

[1] See page 366 of this volume. Tayinloan is about one mile N. of Killean; Whitehouse, 7 miles E. 15° S. of Kilberry; Bellochantuy, 7½ miles S. 10° W. of Killean.

After this prominent vibration, or "blow," the tremulous motion was again felt, and lasted for five seconds. During the whole time that the tremors lasted, a sound was heard "resembling the noise of stones falling down a chimney," loudest at the moment when the "blow" was felt, a dull "thud" being then heard "as of a suppressed explosion."

The intensity was V. at Clachan, and at Tarbert not less than IV.

About noon on the same day, a second shock was felt at Clachan; but, so far as I know, by one observer only.

*Authorities.*—For the information on which the above short account is furnished I have pleasure in thanking: Bellochantuy, Miss M. Currie; Clachan, Rev. J. Cameron, Mr. A. McLellan; Glen Saddell, Mr. J. McLeod, of Saddell; Gigha, Mr. R. A. Cavana, Rev. J. F. McKenzie; Lochranza, Rev. J. Johnstone; Tarbert, Mr. J. Brown.

### Earthquakes at Invergarry and Feddan.

The earthquakes at these two places[1] are interesting owing to their possible connexion with the great fault which follows approximately the course of the Caledonian Canal. Invergarry lies about a mile N.W. of the centre of Loch Oich, and Feddan about three miles N.W. of the centre of Loch Lochy. For the following lists I am indebted to the kindness of Mr. John Grant, of Invergarry, and Mr. Murdoch Matheson, of Feddan, both of whom are doing most valuable work in recording the occurrence of earthquake-shocks.

*Invergarry.*

Jan. 5. 2h. 30m., a shock of intensity IV.
,, 16h. 35m.
,, 16h. 40m.
,, 16h. 47m., like a heavy carriage passing.
Jan. 19. 16h. 55m., the same.
Mar. 15. 8h. 45m., resembled the noise of a heavy train.
May 29. 16h. 45m., like a heavy carriage passing.
Aug. 8. 15h. 35m., the same.
Nov. 16. 20h. 30m., like a passing train. Though occurring at the same time as the fourth shock of the Inverness series, this must have been a distinct shock.
Dec. 1. 10h. 10m., a slight shock.

*Feddan.*

Nov. 19. 1h. 33m., a very slight shock, preceded by a low rumbling noise.
Dec. 26. 18h. 10m., a loud noise resembling thunder heard, followed by a trembling motion, lasting fully two minutes. Almost immediately afterwards, another and louder sound was heard, without any accompanying tremor.

[1] At both places, the shocks are recorded by only one observer, and should therefore, strictly, be regarded as doubtful shocks; but I have placed them under a separate heading, as both observers have for several years diligently recorded the occurrence of every shock felt by them.

### Doubtful Earthquake.

Jan. 6, between 1h. and 2h., Tulliallan (south of Perthshire).

The following account is taken from a paragraph in the "Perthshire Advertiser" for Jan. 8. "Between one and two o'clock .... what is believed to have been an earthquake shock was distinctly felt in the parish of Tulliallan. The night was extremely stormy, with thunder and heavy sleet showers. But readily distinguishable from the sound either of the wind or of the thunder there arose a roaring noise like that of an express train passing at full speed, accompanied by a trembling sensation of the ground, such as Londoners who dwell near the Underground Railway are accustomed to. The noise seemed to increase in intensity as it approached, and then died away again in the distance, just as that of a passing train would have done. There is no railway within several miles."

This is the only account I have been able to obtain. From the description, it is obvious that the shock closely resembled that of an earthquake, but, considering the circumstances of its occurrence, the evidence is not sufficient in itself to establish its seismic origin.

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## IV.—Lower Greensand and Purbecks in the Vale of Wardour, Wilts.

By the Rev. P. B. Brodie, M.A., F.G.S.

IN the Geological Magazine for July last the Rev. W. Andrews and Mr. Jukes-Browne gave an account of Lower Cretaceous strata in the Vale of Wardour. I can bear testimony to the correctness of this statement. Many years ago, when geologizing in the vale chiefly among the Purbecks, I found many portions of ironstone and hard ferruginous sandstone, in the fields and by the roadside both at Dinton, Teffont and especially at Chilmark, containing casts of *Cyrena*, *Turritella*, and a part of a dermal scute of a Saurian, which I believe belong to the Lower Greensand, but I never saw it *in situ*, and it seems to have been greatly denuded. A few years ago, after an absence of nearly fifty years, I paid another visit to some of my old haunts in this beautiful district, in company with Mr. Andrews, who was anxious to find out the exact spot where I obtained insects, fish and *Archæoniscus*; but after a careful search no trace of the old quarry could be seen, and the place was filled up and overgrown with bushes. In no other locality in the Vale has a similar limestone been found, though *Archæoniscus* and a few remains of insects occur lower down in the Middle Purbecks at the lime quarry above Teffont Rectory, where Mr. Andrews has obtained several new and interesting fish,[1] plants, and other organisms. At Dinton the insects were fairly abundant, and *Archæoniscus* especially

[1] Among these fish is *Coccolepis Andrewsii*, A. S. Woodw., which is allied to *Palæoniscus*, and is now in the Jermyn Street Museum. Mr. Smith Woodward lately showed me another remarkable small fish sent to him by Mr. Andrews from Teffont, which the former will shortly figure and describe. These, added to the others long ago figured and described from Dinton, make a most interesting list of new forms from the Wiltshire Purbecks. The other genera from Teffont include *Pleuropholis*, *Microdon*, showing the teeth *in sitû*, and *Lepidotus minor*.

so. It seems probable that the insect limestone below the Archæoniscus bed there is of limited extent, though if pits were opened at the same spot more of the limestone would be found.

The cutting in the railway close by exposed the Isopod limestone, but no trace of the Insect bed was seen, as the excavation at this spot was not deep enough to reach it. At Chicksgrove, in the large quarry then opened near Tisbury, at the base of the Purbecks, I only obtained one elytron of a beetle, but some *Archæoniscus* very much larger than those at Dinton and Teffont. This may be a new species, but has not been figured or described. It is twice as large as the specimen figured in Fossil Insects, pl. i. fig. 7. Owing to the rough nature of the matrix, probably 'the cap' of the Isle of Portland, these are not so well preserved as those from Dinton and Teffont. This Isopod Crustacean evidently ranged from the base of the Lower Purbecks at Chicksgrove, through the lower part of the Middle Purbecks at Teffont to the upper division at Dinton. In one specimen of *Archæoniscus* from Durlstone Bay, Dorset, the Isopod is lying on its back, showing all the legs folded together under the abdomen,—the only example I ever obtained in this position. The recent discovery by Messrs. Andrews and Browne of Upper Purbecks in the Vale of Wardour, hitherto supposed to be absent, is of much interest to geologists, especially to those who, like myself, have long studied these beds.

## V.—Note on an Undescribed Area of Lower Greensand or Vectian in Dorset.

By A. J. Jukes-Browne, B.A., F.G.S.

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UNTIL recently no outcrop of the Vectian or Lower Greensand was known to occur between Lulworth on the coast of Dorset and the neighbourhood of Devizes in Wiltshire. It was supposed that, with the exception of a small area of Wealden in the Vale of Wardour, the whole of the Lower Cretaceous Series in Dorset and South Wilts was concealed and buried beneath the overlapping Upper Cretaceous strata. A recent examination of this district however has revealed two areas where the Vectian sands emerge from beneath the Gault. One of these has already been indicated in the pages of the Geological Magazine;[1] the other is the subject of the present communication.

Reference to the Geological Survey Map, Sheet 15 will show that the Gault was supposed to thin out and disappear near Shaftesbury so as to allow the Upper Greensand to rest directly on the Kimeridge Clay. This proves to be a mistake; the Gault is continuous below the Upper Greensand into and beyond the valley of the Stour. Moreover, two miles south of Shaftesbury and a little east of the hamlet of Twyford a tract of sand emerges from beneath the Gault and forms a terrace which for a little distance has an escarpment of

[1] The Lower Cretaceous Series in the Vale of Wardour, by A. J. Jukes-Browne and W. R. Andrews, Geol. Mag. for July, 1891, p. 292.

its own. Near Bedchester this terrace, or dip-slope, is nearly half a mile wide; thence it can be traced southward to Farrington, where it bends westward, still making a prominent feature, and passing above Fontmell Parva it runs into a hollow by Child Okeford on the eastern side of the Stour valley.

The length of this tract is between four and five miles, but only two good exposures have yet been found along it. These are, however, sufficient to give some interesting details of the beds which constitute it. One of them is a road-cutting by Piper's Mill, between Bedchester and Fontmell Magna, and to expose this more clearly two narrow trenches were cut down the bank. By this means the following beds were observed:—

| | Feet. |
|---|---|
| Brown loamy soil ... ... ... ... ... ... ... ... | 1 to 2 |
| Mottled brown and grey clay containing in the lower part pebbles of vein quartz and lydianite as large as beans (? base of Gault). ... ... ... ... ... ... ... ... | 2 |
| Greenish-brown sand with clay mottlings ... ... ... | 2 |
| Soft purple brown clay (1 foot) passing into dark green sandy clay, with laminæ of purple clay and patches of greenish-brown sand, and finally into mottled sand, brown, yellow, and green ... ... ... ... ... ... | 5 |
| Purple black laminated clay and sand ... ... ... ... | 1 |
| Greenish-black clay full of glauconite grains ... ... ... | 2½ |
| Hard brown sandstone cemented with oxide of iron ... | 0½ |
| Rather coarse yellowish-brown sand... ... ... ... ... | 1½ |
| Fine soft greenish-grey sand, seen for ... ... ... ... | 2 |
| about ... ... | 18 |

The other exposure in a sand-pit east of Bedchester seems to begin where this leaves off. It shows remnants of the ferruginous sandstone underlain by greenish-brown sand with two layers of coarse yellowish sand and then 6 feet of fine greenish brown sand, below which is some 5 or 6 feet of dark-green glauconitic sand. This last is well exposed along the gully of the watercourse that runs by this spot toward Piper's Mill.

From these particulars it appears that the total thickness of the sands near Bedchester is at least 30 feet, and probably between 30 and 40 feet. There are some thin layers of coarse quartz sand in the upper part, but the greater part is fine sand consisting of small even-sized grains of quartz (not much rounded), and grains of dark-green glauconite, many of which are smaller than the quartz-grains.

The occurrence of the dark glauconitic mud or clay is particularly interesting, both as showing that we are not here dealing with a littoral or very shallow water deposit, and also because a similar bed, consisting of black clay in the upper part and dark greensand below, was found in the Vectian of the Vale of Wardour. The bed at Piper's Mill appears to consist of an intimate mixture of dark purple-grey clay and very fine glauconitic sand, chiefly glauconite, with some minute grains of quartz and mica.

It may be mentioned that a boring made at Fontmell Brewery a few years ago has been carried through the Gault into sand

similar to that above described, and a good supply of water was obtained which rises above the surface of the ground.

It is also worthy of note that this emergent tract of Vectian sand is the most westerly exposure yet known, with the exception of that near Lulworth Cove, which, however, is of much smaller size, compared with the tract above mentioned. It happens too that this tract, and that near Lulworth, are almost exactly on the same line of longitude.

Considering its position, the amount of glauconite present, the fineness of the sand, and the existence of interstratified clay are remarkable facts, suggesting that the deposit was formed at some distance from a shore-line. Comparison with the exposures near Devizes and Seend certainly suggests that the latter were formed in much shallower water and much nearer a coast-line.

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## VI.—On a Specimen of *Waldheimia perforata* (Piette), showing Original Colour-markings.

By Edward Wilson, F.G.S.,
Curator of the Bristol Museum.

THE retention of the original colour-markings amongst fossil Brachiopoda is a somewhat rare occurrence: the following striking instance therefore seems worthy of record.

It is true that Deslongchamps in the Paléontologie Française mentions the colours of a number of Jurassic Brachiopods, but in nearly all these cases the colours are spoken of as if uniformly distributed and not patterned over the shells,[1] and therefore we cannot be sure that they are original and not subsequently produced.

Of British fossil Brachiopods which show the colour-markings, *Terebratula hastata* and *Discina nitida* respectively from the Carboniferous Limestone of Longnor, Derbyshire and Hamilton, Scotland, *Terebratula intermedia* from the Cornbrash of Wollaston, and *Terebratula biplicata* from the Upper Greensand of Cambridgeshire, are examples.[2] In these cases the colour-marks are generally in the form of radial, *i.e.* vertical bands or striæ.

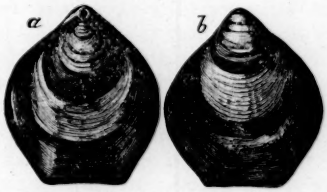
The specimen to which I now call attention is one belonging to the species *Waldheimia perforata*, Piette, and comes from the Lower Lias of Bitton, Gloucestershire.

The colour indications on this shell are in the form of clearly defined concentric bands of black and white of varying breadth, conforming approximately but not rigidly with the lines of growth. The bands of colour are bilaterally symmetrical, and, what is still more important as indicating that they are original, correspond in the two valves, except that as we should expect they are broader in the larger and more rapidly growing ventral valve, and show a tendency in that valve to split up into smaller rings. Commencing at the beaks we have in each valve a white circular area crossed by

[1] The colour of *Waldheimia perforata* for example is given by this author as "brun foncé violacé."

[2] *Vide* T. Davidson, Palæont. Soc., British Fossil Brachiopoda, vols. i. ii. and iv.

three nearly equidistant and narrow black rings, then a broad black band which in the ventral valve is imperfectly divided into three black rings by two narrow white streaks; then a broad white lunate area shading off into black towards the horns, and finally a broad black band which, with the exception of a slight white mottling in the ventral valve, extends without interruption to the frontal margin. What the actual colours were in the living shell it is impossible to say, but from the markings, still retained, in this solitary specimen, *Waldheimia perforata* appears to have been a decidedly handsome organism.




*Waldheimia perforata*, Piette, showing original colour-markings. *a*, front view; *b*, back view. Both natural size.

The above specimen is a full-grown and typical example of the species, 23 mm. long, 20 mm. broad, and 13 mm. in its greatest antero-posterior diameter. It was found by my friend Mr. J. W. D. Marshall, of Bristol, in whose excellent collection of British Jurassic Brachiopoda it now is, at the riverside quarry, Stout's Hill, Bitton, where the species is by no means rare. The specimen was not actually found *in sitû*, but the beds from which it was undoubtedly derived are usually referred to the zone of *Ammonites Bucklandi*. From the prevalence, however, of the typical ammonite and the general character of the associated organisms here as well as at other places in the Bristol district, I am inclined to think that this fossil comes from the zone of *Ammonites angulatus*.

## VII.—Notes on the Altered Coniston Flags at Shap.

By W. Maynard Hutchings, Esq.

THE alteration undergone by the Coniston Flags, owing to the intrusion of the Shap granite, has been well and fully described by Messrs. Harker and Marr in their most able and interesting paper, read before the Geological Society in the spring of this year, "The Shap Granite and the Associated Igneous and Metamorphic Rocks" (Q.J.G.S. vol. xlvii. 1891).

I have worked a great deal, microscopically, on the rocks of this district, both before and since the publication of the results of Harker and Marr, and this work has enabled me in a special manner to appreciate the quality and value of their investigations in this complicated and interesting region. I was so fortunate, two summers ago as to spend some time at Shap with Mr. Marr, who most kindly assisted me to understand some of the problems involved, and pointed out to me the places where specimens of special interest could be collected.

For certain reasons I have taken much interest in the altered flags of Wasdale Beck, and have this summer paid another visit and collected a large number of fresh specimens, from which I have had sections prepared.

It may be worth while to note one or two of the results of the study of these and former sections, though all the main points as regards these rocks have been so completely dealt with in the above-mentioned paper.

There are two contact-minerals to record not previously observed here by Harker and Marr, nor by myself, viz. hornblende and garnet. The former occurs in large quantity in two of my sections several hundred yards above the falls near the hotel, but before the development of any of the "spots" in the altered flags. It is a very pale-green variety; so pale that in very thin sections its colour and dichroism are barely perceptible. I suppose that, though not quite colourless, it may be reckoned as tremolite, to which variety the hornblende of contact-slates, etc., is usually referred. The extinction-angles are mostly 16° to 18°, but sometimes higher. It occurs as good-sized irregular grains, long prismatic bits with ragged ends, and small fragments disseminated through the rock. The amount of brown mica present is very much diminished in the sections which contain hornblende.

My specimens are not sufficiently frequent to determine the points of appearance and disappearance of the hornblende along the course of the stream; but at one point a section very full of it was taken a few feet away, *laterally*, from another section which does not contain a trace of the mineral.

Harker and Marr point out that, as the strike of these beds coincides very closely with the line of exposure along the stream, we need not expect any variation in the original nature of the rocks. But they must have varied a good deal within narrow limits *across* the strike. These hornblendic specimens are different in several ways from the more normal rock, notably in the amount and size of the quartz present. Doubtless, also, they were originally calcareous bands, while most of the flags exposed in the beck were not.

Somewhat higher up the stream, and at about the same stage as the development of decided "spots," the garnet appears in great force. It is quite colourless and quite isotropic, with large amounts of included granular and microlithic material not determinable. The garnets are mostly in the form of crystals, but also as rounded and irregular grains. The largest have a diameter of $\frac{1}{200}$ inch. They are mostly pretty evenly dispersed and occur indifferently in the spots and in the surrounding mosaic, but at some parts of the slides they are aggregated into large clusters and packs.

This mineral, again, seems to be very local in its occurrence, appearing and disappearing within a distance of a few yards *along* the slide, and of a few feet *across* it.

One of my objects in taking a new series of specimens was to endeavour, if possible, to obtain more evidence as to what is the real nature of the substance, or substances, in course of formation in

the comparatively clear "spots" which are so prominent a result of the alteration of these rocks. In this I have not been successful. All the spots, however, are not of the same nature. In some cases they appear to consist almost wholly of white mica. In others, after much observation and comparison with other contact-specimens, I am of opinion that, as suggested by Harker and Marr, andalusite is the mineral being formed. But that mineral, in definite recognizable form, does not occur in any of my sections. In other slides, again, the material of the spots is quite different from either of the preceding and quite beyond any attempt at identification.

Messrs. Harker and Marr are of opinion that probably a good deal of felspar is formed in these altered flags, together with the mosaic of regenerated quartz. There are few questions of greater interest than that of the formation of *new* felspar in sedimentary rocks, whether by contact or by regional metamorphism, and any instance brought forward is important. Such instances are not very numerous, and some of them do not appear to be by any means fully accepted. In the case of these rocks in Wasdale Beck I have made every effort to obtain proof of the occurrence of felspar, but without any success. All the grains of the mosaic are perfectly limpid. Many suggest felspar by their outlines, as stated by Harker and Marr, and there is decidedly an impression produced that the mineral is there. But of scores of tests in convergent light, made on promising-looking grains, not a single one has given proof of a biaxial mineral, which would in this case be sufficient confirmation. The sections for studying this class of rock are necessarily very thin; but with equally thin slices of some of the neighbouring altered volcanic rocks with quartz-felspar mosaic, it is quite easy to pick out and identify the felspar grains. Although it is by no means unlikely that felspar is present, I prefer to consider it as not proved, so far as any of my own specimens are concerned.

Although on a minuter scale, great interest attaches to the changes which are undergone, during the alteration of rocks in this class, by the minerals consisting wholly or largely of titanic acid; and these flags of Wasdale Beck are specially suited for observing these changes, as we may here see several of them together which have been noticed elsewhere singly by different observers at different places.

At the falls near the hotel, where alteration is already well advanced as regards formation of brown mica and is distinctly commencing as regards regeneration of quartz, we still see the original "clay-slate needles" in considerable numbers. They are of very small size. The only change seems to be that they are not as equally diffused as in the original rocks, having apparently commenced to disappear at some parts of each slide examined. A few yards higher up, with much increased development of brown mica and regenerated quartz, these minute rutiles have disappeared; and in due course, as the new limpid mosaic is developed, we note the appearance of rounded and ovoid grains of rutile and of crystals of that mineral, which are much larger and relatively thicker and blunter than the original needles. These things, together with other indeterminable

granular and microlithic bodies, appear in the grains of regenerated quartz and assist in distinguishing it from the still remaining clastic fragments.

At another stage still larger rutile crystals are seen in groups and interlacing clusters, mustering strongly at some parts and wholly absent from others.

In some of the sections where "spots" are strongly developed, clusters of beautiful little crystals of anatase are seen, as recorded by Harker and Marr.[1]

At the time when they introduced the note on this mineral into their paper it had been only seen by me in one section. I now have several, from different points along the beck, in which it is plentifully represented, not only as clusters in the spots, but also scattered about in the mosaic.

This appears to be a rare case, as Mr. Harker tells me that anatase is only once previously recorded (by Lossen) as a contact-mineral. It is a very interesting fact that titanic acid as original slate-needles is reabsorbed in some manner, and then reappears, in one and the same rock, either as rutile or as anatase, and that the latter clusters thickly in special spots.

Another form in which the titanic acid reappears is in combination with lime and silica as sphene, granules of which are abundant in some of the sections, though none is seen till after the disappearance of the original rutile-needles.

Again, at some parts of these rocks we have abundant minute transparent plates of ilmenite, largely as perfect hexagonal crystals, thickly grouped together in the spots in just the same manner as we have the anatase. This appearance of ilmenite in contact-rocks, with the corresponding disappearance of original rutile, is pointed out by Rosenbusch ("Massige Gesteine").

Finally, where veins of white mica are formed, we may see, in and along the edges of these little veins, large crystals and grains of rutile, many times larger than any so far mentioned, resembling in size and form those which are seen so abundantly in some schists.

The occurrence of anatase in this manner being apparently so rare, it may be of interest to mention that I have recently observed another instance of it. A specimen of "ash," or fine-grained tuff, which I collected this summer at Falcon Crag, Derwentwater, is made up in about equal parts of volcanic lapilli and small fragments of sedimentary rocks.[2] Some of these fragments are of *altered* rocks,

[1] These crystals, when best developed, are about $\frac{1}{6000}$ inch long. The form is that of a tetragonal pyramid, either simple or showing also prism-faces in narrow bands. In some of the later specimens there are large clusters consisting almost wholly of perfect, or nearly perfect crystals.

[2] These fragments of sedimentary rock are of various slates and grits. Some are very micaceous and chloritic, not very quartzy, full of "clay-slate needles," and not altered in any way. They are like many common types of slates. Others are very quartzy, more like the flags at Wasdale Beck, but even richer in quartz. The alteration of part of these is shown by formation of some of the "regenerated" quartz, and in some cases brown mica is formed, though this is not much developed, a white mica in good-sized flakes being more usual. It is in these altered, more quartzy, grits or flags, or whatever they may be best called, that the anatase crystals are seen.

the nature of the original material and of the alteration being somewhat like what we have in Wasdale Beck; and in these altered fragments several crystals of anatase occur, similar in all respects to those described. They are not clustered together, but scattered about;—the alteration of the rocks has not proceeded so far as the development of any spots.

## NOTICES OF MEMOIRS.

### I.—British Association for the Advancement of Science. Cardiff Meeting, August 20th to 25th, 1891.

List of Titles of Papers Read in Section C, Geology.

Professor T. Rupert Jones, F.R.S., F.G.S., President.

The President's Address.

*Sir A. Geikie.*—Discovery of the Olenellus-zone in the North-west Highlands.

*Sir A. Geikie.*—On some Recent Work of the Geological Survey on the Archæan Gneiss of the North-west Highlands.

*A. Smith Woodward.*—Report of the Committee on the Registration of Type Specimens.

*A. Smith Woodward.*—Remarks on the Lower Tertiary Fish Fauna of Sardinia (see *infra*, p. 465).

*A. Smith Woodward.*—Evidence of the Occurrence of Pterosaurian and Plesiosaurian Reptiles in the Cretaceous of Brazil.

*A. J. Jukes-Browne.*—The Cause of Monoclinal Flexure.

*A. J. Jukes-Browne.*—Note on an undescribed area of Lower Greensand or Vectian in Dorset (see *supra*, p. 456).

*A. C. G. Cameron.*—On the Continuity of the Kellaways Beds over extended areas near Bedford, and on the extension of the Fuller's Earth Works at Woburn, Bedfordshire.

*Prof. W. Boyd Dawkins.*—On the Discovery of the South-Eastern Coalfield.

*W. Topley.*—The Geology of Petroleum and Natural Gas.

*O. C. Dalhousie Ross.*—The Origin of Petroleum.

*Dr. H. Hicks.*—A Comparison between the Rocks of South Pembrokeshire and those of North Devon.

*W. A. E. Ussher.*—Vulcanicity in the Lower Devonian Rocks. The Prawle Problem.

*A. R. Hunt.*—On the Occurrence of Detrital Tourmaline in a Quartz-Schist west of Start Point, South Devon (see *infra*, p. 465).

*C. E. De Rance.*—Report of the Committee on the Circulation of Underground Waters.

*C. E. De Rance.*—Notes on the Discovery of *Estheria minuta* (var. *Brodieana*) in the New Red Sandstone.

*O. W. Jeffs.*—Report of the Committee on Geological Photographs.

*Montagu Browne.*—On *Colobodus*, a Genus of Mesozoic Fossil Fishes.

*C. Davison.*—Report of the Committee on Earth Tremors.

*Dr. H. J. Johnston-Lavis.*—Report of the Committee on the Volcanic Phenomena of Vesuvius.

*Sir R. S. Ball.*—The cause of an Ice Age.

*Dr. H. W. Crosskey.*—Report of the Committee on Erratic Blocks.

*Dr. H. W. Crosskey.*—Notes on the Glacial Geology of Norway.

*Prof. G. Frederick Wright.*—Recent Discoveries bearing on the Relation of the Glacial Period in North America to the Antiquity of Man.

*Dr. H. Hicks.*—On the Evidences of Glacial Action in Pembrokeshire, and the Direction of Ice-flow.

*H. Bolton.*—On some Boulders at Darley Dale.

*P. F. Kendall.*—On a Glacial Section at Levenshulme, Manchester.

*Prof. G. Frederick Wright.*—Recent Discoveries in the Pleistocene Lava Beds of California and Idaho.

*B. Harrison.*—Report of the Committee on Excavations at Oldbury Hill.

*Prof. J. Prestwich.*—Preliminary Note on Excavations at Oldbury Hill.

*Rev. E. Jones.*—Report of the Committee on Elbolton Cave, near Skipton.

*J. Storrie.*—On the Occurrence of *Pachytheca sphærica*, Hooker, and *Nematophycus*, n.sp., in the Wenlock Beds at Ty Mawr Quarry, Rumney.

*Beeby Thompson.*—Report of the Committee on the Lias of Northamptonshire.

*Prof. J. Hoyes Panton.*—The Mastodon and Mammoth in Ontario, Canada.

*E. T. Newton.*—On the Occurrence of *Ammonites jurensis* in the Ironstone of the Northampton Sand Series near Northampton.

*S. S. Buckman.*—The Ammonite Zones of Dorset and Somerset.

*G. R. Vine.*—Notes on the Polyzoa (Bryozoa) of the Zones of the Upper Chalk.

Papers read in other Sections bearing on Geology :—

Section A.—Mathematical and Physical Science.

*Prof. J. Milne, F.R.S.*—Report of the Committee on the Volcanic and Seismological Phenomena of Japan.

*Prof. J. Milne, F.R.S.*—On Phenomena which might be observable, if the Hypothesis that Earthquakes are connected with Electrical Phenomena be entertained.

Section B.—Chemical Science.

*Prof. W. C. Roberts-Austen, C.B., F.R.S.*, and *Prof. A. W. Rücker, F.R.S.*—The Specific Heat of Basalt.

Section E.—Geography.

*Dr. Phené.*—Changes in Coast Lines.

Section H.—Anthropology.

*E. Seward.*—On the formation of a Record of the Prehistoric and Ancient Remains of Glamorganshire.

II.—Remarks on the Miocene Fish-Fauna of Sardinia. By A. Smith Woodward, F.G.S.[1]

THE author referred to a series of fragmentary fish-remains from the Miocene in the neighbourhood of Cagliari, Sardinia, collected and submitted for examination by Prof. D. Lovisato. A memoir on the subject by Prof. F. Bassani (see *infra*, p. 476) had lately appeared, and the present communication contained only brief supplementary observations. In addition to the Selachian genera and species recognized by Bassani, the author identified teeth of *Scymnus*, *Oxyrhina Desori*, *Galeus*, *Aprionodon*, and probably *Physodon*, besides dermal scutes of *Trygon*. The collection comprises no evidence of ganoid fishes, and most of the remains of teleosteans are too imperfect even for generic determination. Traces of Scomberoids and Labroids occur, and there is evidence of a new species of the Berycoid *Holocentrum*. Teeth of *Chrysophrys*, *Sargus*, and other common Mediterranean genera are abundant; and a few detached yellow teeth represent an indeterminable species of *Balistes*.

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III.—On the Discovery of a New Species of Fossil Fish (*Strepsodus Brockbanki*) in the Upper Coal Measures Limestone of Levenshulme, No. 6 Group, from the Railway Cutting at Levenshulme, near Manchester. By James W. Davis, F.G.S. Mem. and Proc. Manchester Lit. and Phil. Soc. [4], Vol. IV. 1891 (reprint paged 1–3).

VERY fragmentary remains of *Strepsodus* in the collection of Mr. W. Brockbank, F.G.S., form the subject of this note. "The teeth differ from those of *Strepsodus sauroides*, Young, in the greater breadth in proportion to the length; the surface striation is similar in the two, with the exceptions that in *S. Brockbanki* the striæ are larger, and there is no evidence of bifurcation, and whereas in *S. sauroides* the base of the crown is ovoid and laterally compressed, and the apex twice bent nearly at right angles, in this species the base of the crown is circular, and the point is not twisted to the same extent."

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IV.—On the Occurrence of Detrital Tourmaline in a Quartz Schist west of Start Point, South Devon. By A. R. Hunt, M.A., F.G.S.[1]

WHILE examining the Devonian cliffs near Street Gate at the north-east end of Slapton Sands, South Devon, in company with Mr. W. A. E. Ussher, F.G.S., the author selected a hard micaceous sandstone of fine grain, occurring as a band between softer rocks, for comparison with a micaceous quartzite or quartz-schist, previously noticed by Mr. Ussher at a point on the coast south of Start Farm and west of Start Lighthouse. The quartz-schist occurs as an impersistent band among the mica-schists west of Start Point.

[1] Abstract of paper read before Section C (Geology), Brit. Assoc., Cardiff, 1891.

Mr. A. Harker, F.G.S., on examining the sandstone, at once pointed out the presence of tourmaline and white mica, of detrital origin; and considered that the rock had the appearance of having been derived from a tourmaline-bearing granite.

On a careful examination of two slides of the quartz-schist,[1] the author detected a single grain of tourmaline. Six additional slides were forthwith prepared, and detrital tourmaline was found in them all. One of these slides contains a pellucid grain of quartz with fluid inclusions and active bubbles; another contains a grain crowded with hair-like inclusions and with one fluid inclusion whose bubble is easily moved by the heat of a wax match. Both these grains could be easily matched in the quartzes of different granites.

The derivation of the quartz-schist from granites of more than one character, but one of which must have been schorlaceous, seems clearly indicated.

The above facts have two distinct bearings, viz. as to the age of the metamorphic schists of South Devon, and as to the derivation of the tourmaline.

The two rocks under consideration, viz. the quartz-schist and the Devonian sandstone, are related to each other in four particulars, insomuch as they contain four constituents common to both, viz. detrital tourmaline, detrital mica, quartz of fine grain, and iron.

It seems difficult to avoid the conclusion that such similar rocks must be of like age and derivation; and that as the sandstone is undoubtedly Devonian, the quartz-schist, one of the metamorphic schists of South Devon, must be of Devonian age also, and not Archæan, as has been supposed by some geologists.

The derivation of the tourmaline is a more difficult question. Whatever may be the age of the mass of the Dartmoor granites, those of a schorlaceous character seem to be post-Carboniferous. Moreover, no tourmaline has been noticed in the granites trawled in the English Channel. There is thus no recognized source of pre-Devonian tourmaline in the neighbourhood of South Devon, yet the source of derivation of the rocks under discussion could not seemingly be remote, or the tourmaline, quartz, and mica could scarcely have kept together. The tourmaline granites of Cornwall would meet the case, if any of these are of pre-Devonian age; but on this point the author has no information.

Besides the tourmaline observed in the rocks at Street Gate and Start Point, the author has noticed the same mineral, occurring in the same way, in a sandstone from near Tinsey Head in Start Bay, and in a sandstone from near Charleton on the Kingsbridge estuary, both of Devonian age.

[1] The hand-specimen selected for slicing was kindly placed at the author's diposal by Mr. A. Somervail, of Torquay.

# REVIEWS.

I.—THE LAKE-DWELLINGS OF EUROPE, BEING THE RHIND LECTURES IN ARCHÆOLOGY FOR 1888. By ROBERT MUNRO, M.A., M.D. Royal 8vo. pp. xl. and 600, with 199 composite Illustrations, containing 2172 separate Figures, and 14 Maps and Plans. (London: Cassell & Company.)

THE study of Prehistoric Man, or the attempt to discover evidences of the early races who first occupied Europe in Prehistoric times, and to interpret these relics by a knowledge of the habits and customs of existing aboriginal races, may certainly be said to have been initiated near the end of the first half of the present century. But the most important discoveries were actually made within the second half; discoveries so vast in importance in connexion with the history of the human race as to excite the attention of the whole scientific world and to result in the development of a literature devoted entirely to Prehistoric Archæology.

In Denmark, England, Belgium, France, Switzerland and elsewhere, the stream of new light seemed never ending. Yet many of these novelties had really been discovered long, long, before, but no one seemed disposed to notice them, nor was any curiosity expressed when their discovery was announced. Then why this sudden enthusiasm? Simply because the public mind had become educated and was *beginning* to take an interest in natural science, and men like Falconer, Prestwich, Lyell, John Evans, Lubbock, Pitt-Rivers, Franks, Boyd-Dawkins and Pengelly in England; Lartet and Christy in France; Keller in Switzerland, and very many others, were able, not only to discover, but to correctly interpret and describe, what they found or saw. It is to the labours and publications of these men that we owe the great advance in Anthropological knowledge to which we have attained, and to the general intelligent interest taken by the public at large in the history of early man in Europe.

Following the sequence of these discoveries, we find primitive man wandering and homeless, save for some cave, or rock-shelter; here as a bold palæolithic hunter of the Mammoth and the Woolly Rhinoceros, or disputing his right to some cave with the Bear, the Lion, or the Hyæna. There, as the humble shore-dweller, feasting upon the oyster or the whelk, the limpet, or the mussel. Or, again, engaged in making excellent harpoons out of Reindeer-antlers, and manufacturing needles out of the leg-bone of the Horse; leaving behind him abundant evidence of his prowess in the chase in the form of well-carved or incised figures of these and other animals, on their antlers or pieces of their bones; unrivalled as a skilful worker in flint and other stone, from the rough to the polished implement of perfect beauty. Nor is this all,—for in those districts of Europe where rivers and lakes abound, we learn that certain Neolithic peoples—probably at a somewhat later period—occupied their shores and banks as mixed fishers, hunters, and even as early agriculturists—if their garden-patches may have deserved

that name; and being possessed of more worldly gear than the earlier Cave-Dwellers, and, though living in communities, were yet a peaceful and less warlike race; they had invented a system of fortified habitations, raised above the level of the water, by means of piles driven into the bed of the river or lake, bearing a platform of horizontal timbers upon their tops, on which the dwellings were placed. These lacustrine habitations were sufficiently far from the shore to protect them from enemies, and yet near enough to be approached by a narrow bridge which could easily be removed or destroyed in case of a hostile attack from the land.

The relics of these dwellings first attracted attention at Ober-Meilen, on the east shore of Lake Zurich, during the winter of 1853–54, when, owing to the extreme lowness of the water of the lake, the heads of numerous wooden piles were exposed, around which were portions of Stag's antlers, stone hatchets and other implements which excited some curiosity. Other finds followed and led to the subject being taken up by Dr. Ferdinand Keller, President of the Antiquarian Association at Zurich, to whom the world is indebted for making known one of the most remarkable archæological discoveries of this century,—a discovery which in its consequential results is unique for the variety and wealth of materials with which it has illustrated that singular but long unknown and forgotten phase of prehistoric civilization in Europe, which found its outcome in the habit of constructing dwellings in lakes, marshes, etc.

Dr. Keller's researches were most extensive and were made known in a series of exhaustive reports sufficient to fill many volumes. They were first translated and the plates redrawn and published in English by Mr. John Edward Lee, F.S.A., in 1866; but, in ten years, Keller's continued researches in Switzerland had so grown, that, to keep pace with them, a second edition was required extending to two large volumes.

"Since then, however (1878), the results of lacustrine researches have been greater and more important than during any previous corresponding period. The 'Correction des Eaux du Jura,' together with various harbour alterations in the lakes of Zürich, Geneva, etc., have been the means of enormously increasing the lacustrine collections of Switzerland. In North Italy not only have new and remarkably interesting lacustrine stations been discovered and exhaustively investigated, as Lagozza and Polada, but the researches in the terremare have been such as to entirely alter the previous opinions held in regard to them. Nor has the progress in this field of research in many other countries in Europe been scarcely less important: in proof of which I have only to mention the additions made to the Scottish and Irish crannogs; the curious fascine-structures brought to light in Holderness, Yorkshire, the novel revelations extracted from the *terp*-mounds in Holland, and other low-lying districts on the coast of the German Ocean; the greatly extended and more accurate details of lacustrine structures in North Germany; the discovery in Hungary of prehistoric mounds analogous

to the terramara deposits of Italy, etc. In short there is hardly any corner of the lake-dwelling area in Europe which has not yielded new materials, throwing more or less light on this strange phase of Prehistoric life."

The present volume, Dr. Munro tells us, originated with the Society of Antiquaries of Scotland, who offered him the Rhind lectureship in Archæology for 1888, and suggested that the course of six lectures should be on the "Lake-dwellings of Europe." These lectures are here printed in extenso, and are very copiously illustrated by drawings of all the most typical antiquities discovered, prepared as far as possible from the actual objects by Dr. and Mrs. Munro, who perambulated the whole of Central Europe with note- and sketch-books in hand visiting, as far as practicable, the sites of lake-dwellings, and searching museums and libraries wherever they thought such relics or records were to be found.

"The eastern limit," we are told, "of the region thus visited may be represented by a line drawn from Konigsberg to Trieste, passing through the intermediate towns of Krakow, Buda-Pesth, and Agram. The materials brought together from this area are, to a very considerable extent, absolutely new to British archæologists." Care has also been taken, as far as possible, not to repeat illustrations given by Keller's translator, except where the objects are the best or the only representatives of their kind. To show how well Dr. Munro has carried out his task, and how great is the area over which he has travelled, we must consult the work itself; indeed, it is one which every student of prehistoric archæology must possess in order to be posted up to date in all the researches which have been carried on since the date of the last English edition of Keller's work.

The first lecture gives an account of the earliest discovery of Lake-dwellings; the settlements of the shores of Lake Zürich; those of Western Switzerland and France (pp. 1–109). Some idea may be formed of the vast number of objects of ornament, weapons, and articles of domestic use, in stone, bronze, earthenware, iron, bone or wood, delineated in this work, when we find that in the 23 page-illustrations to the first lecture alone, there are 517 separate figures engraved.

The second lecture (pp. 110–185) deals with the settlements in Eastern Switzerland, the Danubian Valley, and Carniola. Here is given an account of some curious traps made of wood which have been found in settlements as widely separated as Ireland, North Germany, Styria, and Italy, which it is suggested may have been used as Beaver or Otter traps. As many as 52 individual remains of the Beaver were obtained at Laibach alone, where these supposed beaver-traps were also met with. Four hundred and fifteen objects are figured in the text to illustrate this lecture.

The third lecture (pp. 186–276) treats of the Lake-dwellings and pile-structures in Italy, including the Terramara Settlements in the Po Valley, which are illustrated by 527 figures in the text.

The fourth lecture (pp. 277–348) describes the remains found at

La Tène and in the Lake of Paladru; also the Lacustrine and Marine dwellings in the Lower Rhine District and in North Germany; two hundred and eighty-five of the antiquities from which are illustrated in the text.

The fifth lecture (pp. 349–494) treats of the Lake-dwellings of Great Britain and Ireland, describing the Scotch and Irish Crannogs, etc., with two hundred and seventy-four illustrations.

The sixth and last lecture (pp. 495–554) deals with the Lake-dwellers of Europe, their Culture and Civilization; and is illustrated by 154 figures; making a total of 2172 objects figured, besides fourteen maps and plans.

The protracted period of time represented by these pile-dwellings is attested both by their wide geographical distribution, and by the fact that some flourished at a time when the use of metals was entirely unknown to their inhabitants, as all the tools and weapons recovered from the débris were made of such materials as stone, bone, or antlers of deer, etc. The substitution of bronze for these, marks a decided change in the culture and civilization of the Lake-dwellers—a change which becomes further modified by the introduction of iron.

"We have thus a great variety of lake-dwellings, distinguishable from each other generally by the character of their industrial remains, according to the particular civilization which prevailed at the period of their habitation, some dating back from the pure Stone age, others from the Bronze age, while others again bear the imprint of various later civilizations, as Roman, Celtic, Carlovingian, Slavish, etc., clearly proving their continuance in various parts of Europe for a very long period extending from the Neolithic age to the dawn of written history."

"In hazarding an opinion as to the original founders of the lake-dwellings of Central Europe (writes Dr. Munro), I would say that they were part of the first Neolithic immigrants who entered the country by the regions surrounding the Black Sea and the shore of the Mediterranean, and spread westwards along the Danube and its tributaries till they reached the great central lakes. Here they founded that remarkable system of lake-villages whose ruins and relics are now being disinterred as it were from another or forgotten world.

Those following the Drave and the Save entered Styria, where they established their settlements on what was then a great lake at Laibach. From this they crossed the mountains to the Po valley, where they founded not only the pile-villages, but subsequently the terremare. The Danubian wanderers having reached the upper sources of the Danube, crossed the uplands by way of Schussenried, and arrived on the shores of Lake Constance, from which they quickly spread over the low-lying districts of Switzerland. From Lake Neuchâtel, still continuing a westward course, they reached the Rhone Valley by way of Morges, where they erected one of their earliest and largest settlements. From the Lake of Geneva they had easy access to the lakes of Annecy and Bourget."

"After the collapse of the great Lake-villages it is not singular to find that a knowledge of the system remained among the surrounding nationalities, which subsequently germinated into activity in various sporadic corners, and produced not only the Scottish and Irish crannogs, but the analogous remains in Friesland, North Germany, Paladru, etc. As the great extinct mammals are known to have lingered in the recesses of mountain-ranges and other secluded localities, so the artificial islands or crannogs and other lake-habitations of the Iron Age are but the deteriorated remnants of a doomed system which, like every dying art before final extinction, passed through a stage of decay and degeneration." Dr. Munro's book has afforded us no small pleasure and profit in its perusal, and we congratulate both Dr. and Mrs. Munro on the excellence and abundance of the illustrations, which bespeak a real love of the graphic art.

A descriptive catalogue of all the objects illustrated in the text, also a copious index, and an exhaustive bibliography of lake-dwelling researches in Europe, give to Dr. Munro's volume a completeness which is, alas! too often wanting in scientific works.

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II.—Descriptions of some New or Previously Unrecorded Species of Fossils from the Devonian Rocks of Manitoba. By J. F. Whiteaves. From Trans. Roy. Soc. Canada, Section IV. 1890, pp. 93–110, Plates IV. to X. (Montreal, Dawson Brothers.)

WITH the exception of *Stringocephalus Burtini*, the species described in the present paper are new. They are as follows:—

Pelecypoda.

*Modiomorpha attenuata.*
*Megalodon subovatus.*
*Orthonota corrugata.*

Gasteropoda.

*Pleurotomaria goniostoma.*
*Euomphalus Manitobensis.*

Cephalopoda.

*Orthoceras* (*Thoracoceras*) *Tyrrellii.*

Cephalopoda—*continued.*

*Actinoceras Hindii.*
*Gomphoceras Manitobense.*
*Cyrtoceras occidentale.*
*Homaloceras* (gen. nov.) *planatum.*
*Tetragonoceras* (gen. nov.) *gracile.*
*Gyroceras Canadense.*
,, *filicinctum.*
,, *submammillatum.*

In the Report of Progress of the Geological Survey of Canada for 1874–75 (p. 68), "a Brachiopod resembling *Stringocephalus*" was recorded from "the western shore of Dawson Bay," Lake Winnepegosis, "from slabs apparently derived from the neighbouring cliffs."

Collections made during 1888 and 1889 by the author and Messrs. Tyrrell and Dowling in the neighbourhood of Lakes Manitoba and Winnepegosis, included a remarkably fine series of specimens which the author considers to be specifically identical with the *Stringocephalus Burtini* of British and European areas. "They present nearly all the variations in external form which that protean species assumes," and some exhibit the internal characters. "The only appreciable characters in which the Manitoba specimens seem to differ from British or European ones are, that in the former the loop in the dorsal valve is much broader proportionately, and the

muscular impressions, which, however, are very indistinctly defined, were probably longer."

At Lakes Manitoba and Winnepegosis, all the species described in the paper, with the exception perhaps of *Gomphoceras Manitobense*, and *Gyroceras submammillatum*, were associated with this Brachiopod, a shell which, in Europe, occupies a definite horizon in the Middle Devonian.

Although based upon very meagre material, the species referred to the genus *Modiomorpha* can, it is believed, "be recognized at a glance by its unusually large size and narrowly attenuated form, although it is by no means certain that it is correctly referred to this genus." Since the hinge is not well preserved in any of the specimens collected, the species assigned to the genus *Megalodon* is provisionally referred to that genus on account of its "strong resemblance in external structure to the *M. truncatus* and *M. rhomboidalis* of Goldfuss from the Devonian rocks of the Eifel."

Of the two new Gasteropods which are described, viz. *Pleurotomaria goniostoma* and *Euomphalus Manitobensis*, the latter is stated to be one of the most abundant and characteristic fossils of the Devonian rocks at Lakes Manitoba and Winnepegosis. In addition to detached opercula, one specimen has been found in which "the shell is so broken as to show its operculum *in situ*, though a little displaced from its normal position."

A remarkable species of *Orthoceras* is described under the name *O.* (*Thoracoceras*) *Tyrrellii*. It has a marginal siphuncle and is ornamented with transverse plications and longitudinal ridges, each point of intersection of a transverse plication with one of the longitudinal ridges being marked by a short, slightly curved spine. The author observes that it "seems to belong to that group of the Orthocerata for which Fischer de Waldheim proposed the generic name *Melia* in 1829, though, finding this preoccupied, he changed it to *Thoracoceras* in 1844." Fischer gave as the type of the genus *Thoracoceras*, *Th. vestitum*—a species with a rather small, submarginal siphuncle, and ornamented with spinose. longitudinal ridges. Although adopted by some subsequent writers, the genus has been variously interpreted. According to Prof. Hyatt, who regards the genus as valid, it includes "all those longicone species in which the ridges become spiny or are roughened by the prominence of the transverse striæ or ridges," and also such forms as *Cyrtoceras corbulatum*, Barrande, *Cyrt. canaliculatum*, de Koninck and *Cyrt. Puzosianum*, de Koninck. The author adopts *Thoracoceras*, but regards it only as a subgenus of *Orthoceras*.

The figure given of *Gomphoceras Manitobense* certainly bears out the author's statement that the anterior end of its body-chamber appears to be more like that of *Poterioceras*. The species, however, is rather doubtfully referred to the genus *Gomphoceras* on account of its general resemblance to the *G. eximium* of Hall.

Two new genera of Cephalopoda are described, viz. *Homaloceras* and *Tetragonoceras*. The former is thus characterized—"Shell consisting of a slender tube which is broadly and strongly arcuate, curved in the same plane and much flattened laterally, its venter or

outer border being very narrow, truncated and depressed in the centre. Sutural line consisting of two very narrow saddles with an equally narrow sinus between them on the venter, a broadly concave sinus or lobe on each of the sides, and a rather narrow saddle on the dorsum; siphuncle in the only species known, cylindrical, exogastric, and placed near the venter or outer and convex margin. Body-chamber long, occupying about one-third of the entire length."

The author is doubtful as to which of Prof. Hyatt's families the genus should be referred, but he is "inclined to regard it as an extremely aberrant member of the Hercoceratidæ."

The other new genus—*Tetragonoceras*—is proposed for a loosely coiled shell with a quadrangular transverse section. "*Cyrthoceratites*" *tetragonus*, d'Archiac and de Verneuil, from the Middle Devonian of the Eifel, also has a quadrangular transverse section, but according to Prof. Hyatt's statement, this species, which he places in his genus *Centroceras*, appears to have been a true close-coiled Nautiloid.

Of the three new species of *Gyroceras*, *G. Canadense* and *G. filicinctum* are very like the *G. Eifelense* from the Middle Devonian of the Eifel, while *G. submammillatum* bears a most striking resemblance to an internal cast of the well-known *G. ornatum* from the same horizon and locality. G. C. C.

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III.—Landscape Geology: a Plea for the Study of Geology by Landscape Painters. By Hugh Miller, of H. M. Geological Survey. 8vo. pp. 63. (Edinburgh and London, William Blackwood and Sons.)

THE pictures exhibited in the Royal Academy have at times been subjected to criticism in the pages of "Nature." The representation of clouds, waves, the apparent size of the Moon, and the delineation of rock-structure, have in turn undergone praise or stricture; and it would seem that the unhappy Landscape Artist need make acquaintance with Astronomy and Meteorology, with Geology and Physical Geography, and with Botany and Zoology, if he or she wishes to escape the scientific critic. But the plea of the Artist is that he essays to represent things, not necessarily as they are, but as they appear to him; and Mr. Briton Riviere (quoted in the work before us) says, "It is the personality of the artist, the impress on the work of the artist's own mind and intention, adequately expressed, which gives the art." Hence, "It is possible for a picture to be scientifically true and have no art at all in it; and, on the other hand, to contain several scientific blunders, and yet to be a great work of art."

No one will find fault with the Artist for representing things as they appear to him; but in pictures that aim to be topographical, it is desirable that the outlines of hill and mountain, of crag or scarp, should bear some relation to the anatomy of the earth. Mr. Miller disclaims any desire to go geologizing through the picture galleries, though he agrees with the critic who says, "Is it too much to ask that the artist shall not give us *slate* where there is only *gneiss*, or granite boulders where there are none?"

The author remarks that Geology, like all the teachings of Nature, will be found to be fraught with Poetry, and he urges that it is possible to convey some poetic expression of past time as well as of modern agents in the delineation of both mountains and rocks. He points out the position of blocks in a torrential stream, with their plane sides sloped gently towards the current; and to the shapes and altitudes of boulders on a hill slope. Artists, he says, as a rule look upon rocks as in themselves rather expressionless objects, but he urges that much expression may be given to them when attention is paid to their texture, structure, and colour. He would "make the varying aspects and colouring of rocks the object of special studies—not forgetting that it is possible to find varying expression, and, so to speak, a different handwriting, or perhaps hidden *ciphers*, in the same rock from day to day." In these and other remarks he endeavours to show that Geology taken in connexion with the physical aspect of the country may be studied as an exercise for the imagination.

He would wish the artist to "open his mind to ideas of strange vicissitude and awful age in connexion with rocks and mountains," though the mountains be depicted "not as rent and torn by disrupting forces from within, but as wasted and sculptured by the forces of 'denudation' at work without."

In this way Mr. Miller maintains that some acquaintance with Geology would be to the Landscape-painter what a knowledge of History is to the painter of historical subjects. It would help and inspire him in giving expression to his subject.

It is often urged that Geology, dealing for the most part with pre-human periods, can yield little material for poetic minds. The author himself observes, "Ruins are pregnant with human associations; rocks have none." But Geology blends its History with that of Man and many associations may be called up, directly or indirectly, in the imprints of the past upon the present.

Referring to the Scenery of Scotland Sir Archibald Geikie has remarked that if the Geologist "can only present his results in simple and intelligible guise, they will be found in no degree to lessen the charm of the scenery. He cannot diminish the romance that hangs like a golden mist over the country; on the contrary, he reveals another kind of romance, different indeed in kind but hardly less attractive, wherein firth and fell, mountain and glen, glow with all the fervour of a poet's dream." The same writer adds, "Let me, however, assure him [the reader] at the outset that if the human associations of the land are uppermost in his mind as he wanders through it, my sympathies are wholly with him." A Geology made easy for Landscape Artists is still a desideratum. There is need of a work that would simply describe types of rock-structure and the relations between various rocks and the form of the ground. Mr. Miller has in the little book before us discussed his subject in such choice language and in so poetic a spirit, that we are led to hope that he may supplement his *plea* by some more practical guide for the use of the Landscape-painter.

## IV.—Tertiary Fishes.

1. Neue Untersuchungen an tertiären Fisch-Otolithen. By Prof. Dr. Ernst Koken. Zeitschr. deutsch. geol. Ges. 1891, pp. 77–170, Pls. I.–X. Woodcuts 1–27.
2. Palaeoichthyološki Prilozi (Collectae Palaeoichthyologicae). Part II. By Dr. D. Gorganović Kramberger. Rad jugoslav. Akad. 1891, pp. 73, Pls. VIII.
3. Contributo alla Paleontologia della Sardegna. Ittioliti Miocenici. By Prof. Francesco Bassani. Atti R. Accad. Sci. Napoli, Ser. 2, Vol. IV. Mem. No. 3, 1891, pp. viii.+60, Pls. II.
4. Ueber einen mit hyperostotischen Bildungen versehenen Schädel eines subfossilen *Pagrus* von Melbourne. By Prof. Dr. W. Dames. Sitzungsb. Ges. naturf. Freunde Berlin, 1890, pp. 162–167, Woodcut 1.
5. Sciame di Pesci fossili ricoprente una Lastra di Calcare marnoso. By Dr. Carlo Pollini. 8vo. pp. 1–8, Pl. I. (Milan, 1891.)

DR. ERNST KOKEN, now Professor at Königsberg, is continuing his well-known researches in the determination of fish-otolites; and his latest contribution to the subject, mentioned above, concludes with some general remarks of much interest. It is a surprising fact that a large number of groups of fishes that must have existed from early Tertiary times are scarcely, if at all, represented by tolerably complete fossil skeletons, or by readily recognizable fragments. If, however, Dr. Koken's determinations of the fossil otolites are well founded, this circumstance is proved to be merely another example of the imperfection of the "geological record"; and whole groups of which the palæontologist has hitherto known almost nothing are shown to occur in comparative abundance at certain horizons in several classical localities. Of the Gadidæ much evidence of the genera *Gadus*, *Morrhua*, *Merlangus*, *Raniceps*, and *Merluccius* is recorded, especially from the Oligocene of Germany. Many otolites of Ophidiidæ are also discovered in the same horizon, but the genus *Fierasfer* alone can be more precisely determined. Macruridæ seem to be recorded among fossil fish-faunas for the first time; otolites of *Macrurus* itself being recognized in the Pliocene of Tuscany, and some generically indeterminable specimens occurring both in the Lower Oligocene of Lattdorf and in the Senonian of Siegsdorf. With reference to the latter, Dr. Koken remarks that he does not consider either of them abyssal forms, but more nearly approaching the typical Gadidæ. Of the Anacanth Flat-fishes even otolites are scarce and very difficult to determine. *Platessa* and *Solea* are recorded from the German Oligocene, and the former also occurs in the Phosphates of Alabama. The remarkable Berycoid genera *Hoplostethus* and *Monocentris* are believed to be indicated by otolites from the Eocene of Copenhagen, the Oligocene of Germany, and the Pliocene of Tuscany; and undetermined genera of the same family are also recorded from the German Oligocene. Sciænidæ are well represented in the Upper Oligocene and Miocene. Most of the Percidæ are as yet generically indeterminable, from want of recent

material for comparison; and the same remark applies to the Gobiidæ. Sparidæ, as might be expected, are widely distributed; and the Cataphracti seem to be represented in the German Middle Oligocene by the genera *Trigla*, *Peristedion*, and *Agonus*. These determinations, as Dr. Koken points out, add considerably to the material available for a discussion of the distribution of the Tertiary Teleostean Faunas in Europe; and the author is finally tempted to devote no less than seventeen pages to a treatise on otolites in reference to their bearing on the classification of Fishes.

Dr. Kramberger's new work is of a different character from that of Dr. Koken, being based upon a series of remains of skeletons, which are beautifully figured in the accompanying plates. It is unfortunately written in a language that few can read; but the scientific diagnoses and principal headings are also given in Latin and thus made accessible to all. There are seven short chapters relating to as many fish-faunas, chiefly Tertiary; and several new species are determined. The first chapter deals with Cretaceous species from Lesina, already described under the names of *Clupea lesinensis*, *Scombroclupea macrophthalma*, *Thrissops microdon*, *Hemielopopsis Suessi*, and *H. gibbus*. The second chapter is more extensive and relates to the marine fishes of the Aquitanian Formation of Styria. Here several new species are determined and named respectively *Labrax latus*, *L. Mojsisovicsi*, *L. sagorensis*, *Sparnodus inflatus*, *Lichia alta*, *Zeus Hoernesi*, and *Z. robustus*. A supposed *Leuciscus* (*L. eibiswaldensis*, sp. n.) is also represented by an imperfect skeleton from the freshwater beds of Eibiswald in Styria, associated with *Leuciscus macrurus*, Ag., and *Gobius brevis*, Ag. sp. Teeth from the Miocene of the neighbourhood of Agram are discussed in chapter iii. and referred to *Chrysophrys*, *Aetobatis*, *Hemipristis serra*, and *Sphyrna* cf. *prisca*. The fish-remains of the well-known Sarmatian beds of Croatia form the subject of chapter iv. and include some new forms, notably *Syngnathus affinis*, *Apostasis* (gen. nov. Acronuridarum) *Sturi*, *A. croatica*, *Scomber* (*Auxis*) *sarmaticus*, *Blennius fossilis*, *Atherina sarmatica*, and *Labrus* (*Crenilabrus*) *Woodwardi*. The generic name *Metoponichthys* is relegated to the synonymy of *Proantigonis* among the Carangidæ. Chapters v. to vii. are brief notes on fragments, of which the most striking are the remains from the late Tertiary beds near Sofia, Bulgaria, described under the new specific name of *Lucioperca Skorpili*.

Thanks to the explorations of Prof. Dr. D. Lovisato, of Cagliari, some information concerning the Miocene fish-fauna of Sardinia is now forthcoming. In the memoir quoted above Prof. Bassani has employed the new material not only for detailed descriptions but also as the basis of an elaborate treatise on the distribution of some of the commonest Tertiary Selachian teeth. *Carcharodon megalodon*, *C. auriculatus*, *Galeocerdo aduncus*, *G. minor*, *Hemipristis serra*, *Lamna salentina* (including "*Otodus Lawleyi*"), *Notidanus primigenius*, *Odontaspis contortidens*, *O. cuspidata*, *Oxyrhina hastalis*, *Sphyrna prisca*, and a species of *Squatina* are recognized among the Selachian teeth; and unsatisfactory fragments of dentition of Teleostean fishes

are assigned to *Chrysophrys cincta*, *Dentex*, and *Thyrsites Lovisatoi* (sp. nov.).

Finally, two smaller papers may be mentioned among recent interesting contributions to knowledge of Tertiary fishes. Dr. Dames has described the skull of a sub-fossil *Pagrus* from the neighbourhood of Melbourne, Australia, giving a good figure and discussing the remarkable hyperostoses by which the cranial roof is characterized. Dr. C. Pollini publishes a photograph of a slab of marl, probably from Aix-en-Provence, in the Genoa City Museum, displaying a shoal of *Lebias cephalotes*, Ag. A detailed description of this fish is given, and some remarks are added as to a possible explanation of the occurrence of so large a number of individuals in so small an area. Dr. Pollini has omitted to observe that Dr. Sauvage some years ago (Bull. Soc. Géol. France [3] vol. viii. p. 445) proposed to place *L. cephalotes* in a new genus, *Prolebias*—a subject that might have been appropriately discussed after the detailed description. A. S. W.

## V.—The Lower Permian Fishes of France.

Etudes des Gîtes Minéraux de la France: Bassin Houiller et Permien d'Autun et d'Epinac. Fasc. III. Poissons Fossiles. By Dr. H. E. Sauvage. 4to. pp. 31, Pl. V. (Paris, Imprimérie Nationale, 1890.)

THOUGH dated 1890, this interesting work on the Permian fishes of the neighbourhood of Autun has only just been brought to our notice. It is a well-illustrated, detailed account of a fish-fauna, of which much has long been known; and it forms an appropriate supplement to the memoirs of Prof. Gaudry, who has devoted special attention to the associated Amphibian and Reptilian fossils.

After a brief historical and bibliographical sketch (in which the only omission we detect is that of Egerton's well-known memoir in the sixth volume of the Geological Society's Quarterly Journal), Dr. Sauvage proceeds at once to a detailed description of the species. The majority of the forms are Palæoniscid fishes related to the Lower Permian genera, *Palæoniscus* and *Amblypterus*; three only being referable to the lower orders, namely, an undetermined species of *Acanthodes*, a Pleuracanth Elasmobranch, and a Dipnoan fish. The generic name *Amblypterus* is employed in almost as extended a sense as is adopted by Traquair, and five species are determined, including two novelties. The so-called new genera *Ædua* and *Archæoniscus* (this name preoccupied by a well-known Isopod) are based on characters which we venture to regard as of very doubtful value; and we are inclined (with Traquair) to disbelieve that the fin-rays in any of these fishes are invested with scales, as Agassiz originally maintained, and as is now re-asserted by Dr. Sauvage. Moreover, we cannot perceive much difference between the type-specimen of *Ædua Gaudryi* and Egerton's *Palæoniscus Beaumonti*, which Dr. Sauvage appears to have overlooked. One small new species is assigned to *Palæoniscus*, and another may possibly represent *Rhadinichthys*. Finally, among the Palæoniscidæ is placed the fish originally

named *Pygopterus Bonnardi* by Agassiz, not hitherto described. It is gratifying at last to have a good figure and description of the fossil to which this name refers; but we fail to recognize the slightest resemblance to *Pygopterus*, and until Dr. Sauvage is able to bring forward further evidence on the subject, we shall continue to believe that *P. Bonnardi* is founded on part of the caudal region of a Pleuracanth Elasmobranch.

Of the Dipnoan fish described by Gaudry as *Megapleuron Rochei*, and of the Pleuracanth spine named by the same author *Pleuracanthus Frossardi*, Dr. Sauvage merely reproduces the original descriptions and figures. No allusion is made to Dr. Anton Fritsch's observations on *Megapleuron*, in which the rhomboidal scales are correctly, as we consider, assigned to a fragmentary Palæoniscid mingled with the skeleton. This correction is of importance, for it enables "*Megapleuron*" to be recognized as a typical Sirenoid Dipnoan.

There is now hope that Dr. Sauvage's long-promised memoir on the Palæoniscid fishes of the Coal-measures of Commentry will not much longer be delayed; and we await with interest the further contribution to our knowledge of this intricate group of fishes.

A. S. W.

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VI.—The Geology of the North-East of Caithness, and a Discussion as to the Age of the Old Red Sandstone of the North of Scotland. By John Williams Evans, LL.B., B.Sc., F.G.S. Pp. 48, with Sketch-Map. (London: Green, McAllan and Feilden, 1891.)

IN this pamphlet the author gives us the result of six weeks' field-work in Caithness. The county is occupied almost entirely by the Old Red Sandstone with coverings of Glacial Drift; it is to the older formation that attention is now directed.

Murchison divided the Old Red Sandstone of Scotland into three portions: the *Lower*, including the Arbroath flags, with *Cephalaspis*, *Pteraspis*, and *Pterygotus*; the *Middle*, including the Caithness flags, with *Osteolepis*, *Asterolepis*, *Pterichthys*, etc.; and the Upper, including the Dura Den beds, with *Pterichthys*, *Holoptychius*, etc.

Sir Archibald Geikie afterwards referred the Caithness flagstones to the Lower Old Red Sandstone, and maintained there was no evidence of any Middle division.

The observations of the author lead him to maintain that the Old Red Sandstone of Caithness belongs entirely to the Upper division; and he thus represents the succession of the Scottish Upper Old Red Sandstone:—

| | | | |
|---|---|---|---|
| Upper Old Red Sandstone. | Zone of *Bothriolepis*. | Sub-zone of *Bothriolepis hydrophila*, *Holoptychius Flemingi*, and *Glyptopomus minor*. | Dura Den, etc. |
| | | Sub-zone of *Holoptychius nobilissimus* and *Cricodus favosus*. | Scat Craig, Clashbennie, etc. |
| | Orcadian. | Sub-zone of *Microbrachius Dicki* and *Tristichopterus alatus*. | |
| | | Caithness Flags, Orkney and Shetland beds, and the Old Red Sandstone of Cromarty, Gamrie, etc. | |
| | | Basement Conglomeratic series. | |

# CORRESPONDENCE.

## THE STUDY OF MAMMALS.

Sir,—I am indebted to the reviewer of this work in your last number for pointing out that the family *Tritylodontidæ* occurs twice in the systematic table. Its second occurrence is not, however, as he supposes, an inadvertent repetition, but a "misprint" for *Triconodontidæ*. Another slip occurs on p. 99, where in giving the range of *Oryx* Persia stands instead of Syria. R. Lydekker.

## DYNAMIC METAMORPHISM "AGAIN."

Sir,—Personally I am sorry to be called upon to point out briefly that Mr. Fisher (Geol. Mag. Sept. 1891, p. 430) has made the mistake of substituting exclusion (or "outness") in space for *logical* exclusion of one term from a series of other terms used in a train of reasoning, and that this misconception seems to run through the whole of his letter except the last paragraph. It is not Mr. Fisher's $(P - W)\,w$, but the "*last term*" *of the four which I had just enumerated* (p. 299), which is logically outside the other three. To say that it is outside the cubic unit (not "element") of the mass, on which the work is done, is something to which I am unable to attach any meaning at all. The energy, to which the motion of the train (in my illustration) is due, is *dissipated* (not annihilated or necessarily "converted" into some other form of energy) according to the ordinary laws of thermodynamics, having been obtained as heat from the potential energy of the fuel and atmospheric oxygen, and utilized, while in a condition of high intensity (the $H_2O$ being the carrier of the energy), to move the piston of the engine with the load attached. In running down from a state of high intensity (in which work can be got out of it) to a state of low intensity (in which it is either absorbed by surrounding bodies, or passes off by radiation into the general entropy[1] of the universe), there is no destruction, there is only dissipation, of energy; and when it is thus dissipated, you cannot get any more work out of it. If energy were (under the conditions specified) "stored up in the train," after it had come to a standstill (the idea which was before my mind, though, I fear, not explicitly stated), the train would be, after translation, in a *position of advantage with respect to motion*, as compared with its position before translation, which is absurd. Certainly during the accelerating stage of translation energy is being stored in the train, just as you store energy in the weight of a clock in winding it up; but the same amount of energy is taken out of the train in bringing it to a standstill, just as it is taken out of the clock-weight, when it runs down. There is therefore no more energy stored in the train, after it has come to rest, than there is in the weight and works of a clock after it has run down. So in the case of the rock-mass under consideration, the source of the energy is gravitation. The work done on the rock is only a case of

[1] "Entropy" in the sense in which the word was first used by Clausius.